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SOCIAL INFLUENCES ON AFFECTIVE RESPONSES TO NEGATIVE EXPERIENCES

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SOCIAL INFLUENCES ON AFFECTIVE REPSONSES TO NEGATIVE EXPERIENCES

THESIS FOR DOCTORAL DEGREE (Ph.D.)

By

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To my dear Loa,

I hope this work will one day inspire you to also follow your dreams

and make what you are most passionate about into your work.

POPULAR SCIENCE SUMMARY OF THE THESIS

The overall goal of this thesis is to advance our understanding of how the observation of and interaction with others' behavior and emotions can affect the formation, regulation and transfer of our emotional responses surrounding a negative experience. Specifically, we use experimental methods to investigate how the development and the maintenance of symptoms of anxiety disorders and post-traumatic stress disorders are influenced by our interactions with other.

Imagine you are sitting on a plane that goes through turbulence. You might take off your headphones and start looking around trying to grasp what is happening. Let's say you see the flight attendant rushing to their seat and putting their seatbelts on. This observation might inform you on the potentially threatening meaning of the situation, which could generate worrying thoughts in you. Had the flight attendant kept walking up and down the aisle instead, it might have signaled that the situation is safe. The effect of observing someone's reaction to a negative experience on the formation of our emotional responses is investigated and discussed in **Study I**.

Seeing a calm person reading their book in the seat next to you versus a very anxious person crying and screaming, might very well influence how you regulate your own emotional response to what is occurring. The way face-to-face and online interactions can modulate already existing emotions is examined in **Study II** and **IV**.

Finally, in the same way that yawning or laughter are "contagious", how a few passengers sitting in the front of the plane react to turbulence can transfer amongst the rest of the passengers and influence how you emotionally respond to the turbulence. How others' perception of the situation can spread from one person to another and influence their emotion is investigated in **Study III**.

This thesis introduce (some of) the psychological and cognitive processes involved in the influence of both face-to-face as well as online social interactions on how we emotionally respond to negative experiences. Our findings show that social interactions can indeed influence how emotions are formed, regulated and transferred, but also calls attentions to the complexity of trying to measure and control experimental social influences.

ABSTRACT

As social human beings, the way we emotionally respond to what happens around us is often regulated by our interactions with others. The overall aim of this thesis is to advance the understanding of how social influences surrounding negative experiences can affect the formation, regulation and transfer of affective responses. Throughout four studies, we examined the impact of different kinds of social influences (face-to-face and online) surrounding various negative experiences (experimental analogues for trauma experiences), and how these social influences impact affective responses (from self-reported measures to physiological responses).

In **Study I**, dyads of participants underwent a vicarious threat conditioning paradigm to investigate whether physiological synchrony between them during learning predicted the strength of observationally acquired conditioned responses and examine the potential role of trait empathy. As predicted, increased physiological synchronization during learning led to a stronger CS differentiation during the test phase, but unlike our predictions, self-reported empathy was not found to be related to physiological coupling. These findings support the role of social influences in the formation of affective responses and indicate that the physiological synchrony captured here may be more related to experience sharing rather than individuals' tendency to empathize with others.

Study II tested whether threat conditioning generated persistent intrusive memories of neutral stimuli, and whether different social support interactions after threat acquisition modulated the expression of emotional memories, as measured by skin-conductance responses and number of intrusive memories. Social support interactions consisted of two social support conditions (supportive social interaction versus unsupportive social interaction) and a control group (no social interaction). Our results indicated that threat conditioning generated intrusive memories, with greater number of intrusions of CS+ than CS- and these intrusive memories were still measurable one year later, especially for individuals with higher trait anxiety and a greater number of previous trauma experiences. Our findings support the literature indicating the contribution of associative processes in the formation of intrusive memories and demonstrate the advantage of adding the measure of intrusive memories to a standard Pavlovian threat conditioning paradigm for investigating short and long term intrusive memories. Finally, these findings suggest that the specific the support interactions used in this study might not modulate the processes underlying memory consolidation and call attention to the difficulty of operationalizing social support interactions in an experimental context.

Study III is composed of two online sub-studies investigating the social transmission of threat and safety evaluations. In sub-study 1, we combined behavioral and computational

modeling approaches to estimate the influence of others' online evaluations of negative pictures on participant's own evaluations. In sub-study 2, we replicated these findings and further demonstrated that others' evaluations led participants to shift their affective response to these pictures. Interestingly, seeing that others evaluate pictures as safe resulted in individuals feeling less distressed towards these pictures, suggesting that the observation of social safety cues online could attenuate the spread of negative emotions. Our findings offer a mechanism for how people integrate their own and others' experiences when exposed to emotional content online. Furthermore, knowing how threat and safety information propagate online and its impact on people's wellbeing could be an important tool to prevent the impact of the spread of threatening information online.

Study IV asked whether using the trauma film paradigm in an online setting could induce similar emotional responses as in-lab experiments. We also tested whether reading previous participants' appraisals after watching the trauma film modulated participants' emotional responses, as measured by changes in negative mood and number of intrusive memories during the subsequent seven days. The trauma film online replicated previous in-lab results, although with a somewhat lower mean number of intrusive memories. Our results indicated that reading positive comments after watching the film decreased negative mood, compared to reading negative comments or no comments. Reading others' appraisal did not modulate the number of intrusive memories. These results demonstrate that the digital version of the trauma film paradigm can be used as an experimental analogue for exposure to aversive content online and enables the experimental investigation of how such content impacts mental health. Moreover, our findings indicate an improvement of mood following the exposure to negative visual content through positive social reappraisal, paving the way towards this goal.

These four studies demonstrate that vast range of ways in which social interactions influence affective responses, from verbal to non-verbal exchanges in both face-to-face and online settings. Our work also illustrates the complexity of experimentally investigating social influences and the specific processes involved.

LIST OF SCIENTIFIC PAPERS

I. Pärnamets, P., **Espinosa, L.**, & Olsson, A. (2020). Physiological synchrony predicts observational threat learning in humans. *Proceedings of the Royal Society B*, *287*(1927), 20192779.

II. **Espinosa, L.,** Bonsall, M. B., Becker, N., Holmes, E. A., & Olsson, A. (2022). Pavlovian threat conditioning can generate intrusive memories that persist over time. *Behaviour Research and Therapy*, *157*, 104161.

III. **Espinosa L.**, Nook, E.C., Asperholm, M., Collins, T., Davidow, J. Y. & Olsson, A. (Under Review). Social Transmission of Threat Evaluations and Feelings of Distress.

IV. **Espinosa L.**, Singh, L., Eimer, T., Olsson, A. & Holmes, E.A. (Under Review). Reading others' social appraisals after viewing an aversive film online impacts mood but not intrusive memories

SCIENTIFIC PAPERS NOT INCLUDED IN THE THESIS

Espinosa, L., Golkar, A., & Olsson, A. (2021). Mentalizing in Value-Based Vicarious Learning. *In The Neural Basis of Mentalizing* (pp. 517-536). Springer, Cham.

Espinosa, L., Kleberg, J. L., Berggren S., Bölte, S. & Olsson, A. (2020). Social learning of threat in autism spectrum disorder. *Molecular Autism*, *11*(1), 1-9.

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Singh, L., **Espinosa, L.**, Ji, J. L., Moulds, M. L., & Holmes, E. A. (2020) Developing thinking around mental health science: the example of intrusive, emotional mental imagery after psychological trauma. *Cognitive neuropsychiatry*, 25(5), 348-363.

CONTENTS

LIST OF ABBREVIATIONS

CS	Conditioned stimuli
US	Unconditioned stimuli
CS+	Conditioned stimuli coupled with a US
CS-	Conditioned stimuli never coupled with a US
CR	Conditioned response
SCR	Skin conductance response
VAS	Visual analogue scale
PTSD	Post-traumatic stress disorder

1 INTRODUCTION

Our emotional responses to events are often regulated through social interactions. These social interactions include various verbal and nonverbal signals that communicate our emotions and behavior to others. Past social interactions drive us to adapt future behavior, because learning from and understanding others is essential. In fact, toddlers use their mothers' non-verbal happy or fearful expressions to guide their behavior about whether or not to cross a visual cliff (Sorce et al., 1985), demonstrating that early on in our development, others' behavior and emotion expressions help us appraise what happens around us. Our survival depends on our ability to overcome complex social situations, and by watching and interacting with others we learn about people, objects, actions and places.

Emotions are social (Parkinson, 1996) and observing others' behavior and affective responses can influence different aspects of our own affective responses. For example, during airplane turbulence, a passenger seeing the flight attendant walking back to their seat and putting their seatbelt on might inform them about the dangerous meaning of the turbulence thereby *generating* worrying thoughts, compared to if the flight attendant kept calmly walking up and down the aisle despite the turbulence. In Section 2.1 I will introduce literature related to the social influences on the formation of affective responses. Additionally, for the same airplane passenger, having a calm versus an anxious person in the seat next to them might influence how they up- or down-*regulate* their own affective responses to what occurs around them, processes which are discussed in section 2.2. Finally, imagine the way how a few passengers sitting in the front of the plane react to turbulence *transfers* amongst the rest of the passengers, similar to the way laughter or crying can be "contagious". Such processes are put forward in section 2.3. Importantly, although these processes are discussed separately in this thesis, they are by all means not independent. A predicament I will also touch on in this thesis.

Affective responses constitute an interaction between many different components including behavior, facial expression, body posture, physiology, subjective experience and brain activities. In this thesis I examine the effect of social influences on three of these components, that is behavior, physiology and subjective experience. Furthermore, this thesis focuses on the affective responses that are formed surrounding a negative experience. Up to 70% of the population have experienced a traumatic event in their lifetime (Benjet et al., 2016) such as "exposure to actual or threatened death, serious injury or sexual violence" (DSM-V, American Psychiatric Association, 2013, p.271). It is therefore of interest to investigate how the social contexts surrounding a negative event impact how one emotionally responds to the event.

The overall aim of this thesis is to advance the understanding of how social influences surrounding a negative experience can affect the formation, regulation and transfer of affective responses. Throughout four studies, we examined the impact of different kinds of social influences (face-to-face and online) surrounding various negative experiences (experimental analogues for trauma experiences), and how these social influences impact affective responses (from self-reported measures to physiological responses).

In the following pages I will introduce the literature related to (some of) the processes underlying the formation, regulation and transfer of affective responses, which we investigated in the four studies included in this thesis. I will then describe the aims of the thesis followed by a presentation of our research approach and key scientific considerations related to these research approaches. Next follows a brief summary of our four studies. Finally, I will discuss the main findings and their general implications and limitations.

2 LITERATURE REVIEW

2.1 SOCIAL INFLUENCES ON THE FORMATION OF AFFECTIVE RESPONSES

Going back to the example of airplane turbulence. For the passenger, seeing the flight attendant's behavior informs them about the dangerous meaning of the situation, which can generate worrying thoughts. In this section, I will introduce some of the literature forming the ground for our investigation of the social influences on the formation of affective responses in **Study I** along with the paradigm used in **Study II**.

2.1.1 Emotional learning

When we interact with our environment, associations are made between threatening events and previously innocuous cues. By enabling us to adapt our behavior to predict and avoid potential threats this form of associative learning serves an evolutionary function and is crucial for our survival. A common experimental model of associative learning is Pavlovian threat conditioning (Pavlov, 1927; Phelps & LeDoux, 2005). In this model, an individual learns the association between a previously neutral stimulus (conditioned stimulus, CS+) and an aversive stimulus such as an electric shock to the wrist (unconditioned stimulus, US), which elicits an aversive response (unconditioned response, UR) such as an elevated autonomic arousal. Another conditioned stimulus (CS-) is never followed by a US. As a result of this learned association, the CS+ gains emotional significance and produces a now conditioned response (CR) and elicits an elevated autonomic arousal even when the CS+ is presented in the absence of the shock. There are different routes to learning these threat associations, one of them is through observation of social cues (vicarious threat learning; **Study I**) and the other is through direct experience (**Study II**).

Although threat learning serves an adaptive purpose, it is equally important to incorporate new information and learn that what was previously threatening is now safe (or no longer dangerous). For instance, when the CS+ is no longer followed by the US, the CS+ then loses its predictive value of the occurrence of the US, which leads to the diminishing of the CR. This process is called extinction of threat response. It is believed that the previous aversive association is not erased, but that a new memory is created (i.e. CS has become safe), which inhibits the expression of the previous threat memory (Myers & Davis, 2007). The persistence of CR to events despite the absence of an US can develop into pathological anxiety. For instance, the underlying processes of (maladaptive) associative learning have been examined in the investigation of fear-related anxiety disorders and post-traumatic stress disorder (PTSD; Duits et al., 2015; Lissek & van Meurs, 2014; Mineka & Zinbarg, 2006; Pittig et al., 2018)

Pavlovian threat conditioning paradigm has enabled the exploration of the role of associative learning in the development and persistence of both the non-declarative (e.g. psychophysiological responses) and declarative aspects (e.g. self-reported CS–US contingency and recognition memory tests) of threat memories (Dunsmoor & Kroes, 2019).

Laboratory experiments using threat conditioning have allowed a very precise investigation of the mechanisms underlying threat responses, which would not be accessible in clinical settings (Carpenter et al., 2019). In fact, variations of the Pavlovian threat conditioning paradigms "present unique translational explanations for the development, persistence, treatment, and relapse of the fear-related features of PTSD" (Zuj & Norrholm, 2019, p.339).

However, this paradigm has rarely been used to investigate *intrusive* memories (Fullana et al., 2019; Holmes et al., 2021). Intrusive memories are recurrent, involuntary, and intrusive recollections of a traumatic event (DSM-V, American Psychiatric Association, 2013), i.e. that come to mind spontaneously rather than being intentionally recalled (Hoppe et al., 2022). One line of research supports the idea that intrusive memories are non-extinguished conditioned responses to trauma reminders and developed a conditioned-intrusion paradigm using complex and naturalistic stimuli (Wegerer et al., 2013). In this paradigm, neutral sounds (CS) were paired with neutral clips versus aversive clips (serving as US) and showed that the sound paired with the aversive clips generated more intrusive images and thoughts of the films, than the sound associated with the neutral clips (Streb et al., 2017; Wegerer et al., 2013). A similar paradigm using neutral faces as CS showed that participants reported intrusive images, sounds, thought and/or feelings of both US (aversive films) as well as the CS (Franke et al., 2021).

The standard Pavlovian threat conditioning using neutral images as CS and electric shocks as US has been (erroneously) assumed not likely to yield intrusive memories (James et al., 2016, p.107; Wegerer et al., 2013, p.2). **Study II** attempted to bridge this gap and tested whether such a paradigm could in fact generate (persistent) intrusive memories of neutral stimuli, both offering a novel experimental model of intrusive memories as well as supporting threat conditioning paradigm as an experimental framework for cognitive processes underlying trauma memories (Fani et al., 2015; Milad & Quirk, 2012; Pittig et al., 2018; Visser et al., 2018; Zuj & Norrholm, 2019).

2.1.2 Vicarious emotional learning

Emotion learning through direct experience was first believed to be the dominant pathway (Askew & Field, 2008). However, psychologists noticed the role of the social context in the facilitation or inhibition of threat responses and put forward the possibility of a social transmission of fear, that is, an indirect acquisition of fear through observation of another individual, also called vicarious learning (Rachman, 1977). Others' behaviors inform us

about potential dangers in our environment. In fact, the fifth version of the Diagnostic Statistical Manual of Mental Disorder (DSM-V, American Psychiatric Association, 2013) specifies the inclusion of "learning about" others' trauma experiences as a component of the criterion for post-traumatic stress disorder (PTSD), recognizing the relevance of indirect trauma exposure.

In a vicarious learning paradigm, a participant (the observer) observes another individual (the demonstrator) whose emotional response following the exposure to the CS+ and CS- functions as a social US and informs the observer about the association between CS and US (Olsson & Phelps, 2007). Later, when the CS are presented to the observer without the presence of the demonstrator, the observer shows an increase in autonomic arousal to the presentations of the CS+ but not to the CS-, indicating that the observer learned the associations vicariously (Berger, 1962). This paradigm has been implemented using video recordings of a demonstrator receiving electric shocks and showed similar results (Golkar et al., 2013; Olsson & Phelps, 2004; Andreas Olsson et al., 2020). Research has indicated that we learn just as well by observing others than we do when learning through direct experience (Olsson & Phelps, 2004), and that both involve similar patterns of brain activity (Lindström et al., 2018; Andreas Olsson et al., 2007).

Vicarious learning is based on the observer's ability to interpret the demonstrator's internal emotional state to the US (Hygge, 1976) . More recent work has shown that vicarious learning can be enhanced for observers who were instructed to actively appraise the thoughts and feelings of the demonstrator's response to the US and that this effect was driven by observers with high trait empathy (Olsson et al 2016).

In **Study I,** we investigated whether experience sharing during observation would promote learning. To do so we developed a novel dyadic setting consisting of two participants (i.e. an observer and a demonstrator). We then examined both their potential physiological synchrony during threat conditioning and whether this synchrony influenced learning.

In the next section, I turn towards introducing some of the processes underlying the social regulation of affective responses.

2.2 SOCIAL INFLUENCES ON THE REGULATION OF AFFECTIVE RESPONSES

In the airplane example, experiencing turbulence and seeing the flight attendant rushing to their seat made the passenger worry about the danger of the situation. In this case, one can imagine that having a calm (versus anxious) person in the seat next to them might influence how the passenger regulates their own affective responses. Here I will first mention emotion

(self-)regulation theories followed by an introduction to ways the social context might modulate affective responses, discussing social buffering and social reappraisal.

2.2.1 Emotion (self-)regulation

Emotions can be harmful if they are of improper intensity, duration or frequency (Gross & Jazaieri, 2014), therefore emotional experiences often generate a need for control over these emotions. To do so, different implicit or explicit (self-)emotion regulation processes can be used to up- or down-regulate positive or negative affective responses. These emotion regulation strategies vary across dimensions from implicit and automatic (i.e. bottom-up) to explicit and controlled (i.e. top-down), and change throughout our development, from more implicit strategies in infants, to more explicit strategies in adolescence and beyond (Silvers, 2020). Adaptive emotion regulation strategies have been found to prevent the development of psychopathology, and a high level of maladaptive regulation strategies can reduce this effect (Aldao & Nolen-hoeksema, 2012).

Emotion regulation takes place at different stages of the emotion-generative process. The modal model, a framework developed by Gross (1998), points out four stages as potential targets for emotion regulation, leading to five emotion regulation processes: Situation (selection or modification of the situation), attention (attentional deployment, e.g. distraction), appraisal (cognitive change via reappraisal, i.e. changing the interpretation of the event) and response (affective response modulation, e.g. suppression of an emotion expression).

Importantly, as emotions are commonly elicited by a specific object and lead to behavioral actions, this model points out the circular form of the emotion-generative process, in which our affective responses give rise to action, which can then alter our environment and also others.

2.2.2 Social emotion regulation

As social human beings, our affective responses don't take place in a vacuum, rather they are broadcast and powerfully influence our environment and the behavior of others (Campos et al., 2011). Similarly, based on features of our environment, interactions with others promote change in the nature, duration or intensity of the emotional experience (Reeck et al., 2016) and lead us to adapt our emotion regulation strategies. For instance, English and colleagues (2017) examined how everyday interpersonal factors determine whether or not we regulate our emotions and which strategy we employ (e.g. distraction, reappraisal or suppression). Their findings showed that in response to the majority of their daily low emotional points and half of their daily high emotional points, the strategy individuals used to regulate their emotion depended on who else was present at the time. Interestingly, they

pointed out that emotion regulation strategies were particularly used during low points where someone else was present (e.g. suppression), compared to when alone (e.g. reappraisal), especially if this someone is not a close one (English et al., 2017).

Similarly to self-regulation, social regulation can influence different phases of the emotion-generative process. For example, the person next to the passenger on the plane can influence their emotion regulation by influencing their attention by distracting them. If the person next to the passenger is their child, the passenger might suppress their affective response so that their child do not get scared. Alternatively, if the child laughs and giggles at the turbulence, the passenger might reappraise its meaning as fun instead of dangerous. Importantly, social regulation is more complex than merely suggesting a regulatory strategy to someone, as these processes take place within the context of the relationship between individuals (Reeck et al., 2016). In fact, depending on the source (e.g. stranger versus family member) and the strategy (e.g. reappraisal versus emotion suppression), the attempt to promote emotion regulation can be seen as unreliable or inauthentic and backfire. A stranger sitting next to the passenger asking them not to show fear during the turbulence might not help them regulate their emotions as efficiently as if their partner had asked them.

Below I introduce two social emotion regulation processes examined in our studies: social buffering (examined in **Study II**) and social reappraisal (examined in **Study IV**). As mentioned earlier, these processes are described separately here, however, in real-life they might well be intertwined.

2.2.2.1 Social buffering

The research in non-human animals originally demonstrated that conspecific animals placed together show reduced stress responses and better recovery after negative experiences (Kikusui et al., 2006), a phenomenon called “social buffering”. The extensive field of research demonstrating the impact of such social modulation on stress responses in animals suggests that these processes are evolutionary and automatic.

In humans, the social buffering effect on stress responses to negative experience has particularly been investigated by looking at perceived or actual social support, which was at the heart of our investigation in **Study II.** Social support is defined as offering or receiving verbal or non-verbal emotional, informational or instrumental resources in response to someone’s need of help (Cohen & McKay, 1984) and can originate either from a natural support system (family or friends) or a formal support system (professional and social community) (Hogan et al., 2002). Research on the buffering effect of social ties and social support on mental and physical health has accumulated substantial evidence and has shown that the absence of social relationships is a serious risk factor for mortality, comparable to

smoking, poor diet or high blood pressure (Gruenewald & Seeman, 2010). Thoits (2011) reviewed the ways significant others or similar others modulate the effect of social support and social ties on physical and mental health. She suggests that on the one hand the emotional and instrumental support from significant others maintains one's belonging, self-esteem and worth which can reduce the physiological and emotional impact of the stressor. On the other hand, informational support from a similar other via advice, encouragement and reappraisal, promotes a sense of control which can result in to better coping techniques in diminishing the consequences of stress (Thoits, 2011).

Experimental work investigating social support on emotional response *during* stressful events is extensive, however findings are somewhat mixed. Using social support reminders (pictures of social support figures) during threat learning was shown to inhibit the formation and to enhance the regulation of learned threat (Hornstein et al., 2016; Hornstein & Eisenberger, 2017), suggesting that the support reminders can impact underlying learning mechanisms. Their potential explanation is that social support figures are safety signals that can alter basic threat learning processes and inhibit threat responses (Hornstein & Eisenberger, 2017). However, in two recent studies social support figures did not modulate verbally instructed threat or safety learning (Bublatzky et al., 2022; Morato et al., 2021).

Another line of experimental work looked at the effect of subliminal presentation of attachment figures on the intrusive memories of traumatic pictures or films. Bryant and colleagues showed that such attachment priming can modulate the number of intrusive memories when occurring during memory consolidation of traumatic images (Bryant & Foord, 2016) but also during memory reconsolidation of images from a traumatic film (Bryant & Datta, 2019). Overall, these mixed findings using pictures of individuals with high quality relationships (loved-ones, i.e. partner, parents or best friends) reflect a limitation in the field of experimental research on social support. The attempt to experimentally operationalize social support as support figures using pictures does not necessarily imply high perceived support, especially in threatening situations.

In real life it is less common to receive support from a calm support or attachment figures during a negative experience. That is why, in **Study II,** we were interested in modeling a situation in which support interactions occured *after* the negative experience with someone who was not a close attachment figure. This would help us examine whether a social support interaction could modulate affective responses to a previously occurring negative event, such as after a car accident. In fact, in the clinical field, trauma research has shown that a lack of social support after a traumatic experience is an important predictor of PTSD (Brewin et al., 2000; Bryant et al., 2017; Ozer et al., 2008). Low levels of support, meaning negative reactions or the absence of supportive behavior by others, have been identified as being strongly related to development of PTSD symptoms (Wagner et al., 2016) and greater PTSD

symptom severity (Ullman & Filipas, 2001). For example, one study mapped the social networks of bushfire victims in Australia and estimated that people's social ties after the disaster were linked to mental health outcomes, more specifically depression and PTSD risk (Bryant et al., 2017).

In **Study II,** we examined whether different short face-to-face social support interactions (supportive social interaction, unsupportive social interaction or no social interaction) could modulate affective responses such as skin conductance and intrusive memories by combining Pavlovian threat conditioning paradigm with the intrusive memory paradigm. As mentioned above, the social support interaction manipulation used in **Study II** was delivered by a stranger in order to model interactions like the one a patient might have with medical staff in the waiting room at the emergency department. However, such interaction is very different from those examined in clinical studies looking at social ties, which is a point we discuss further later on in this thesis.

Should social buffering be referred to as a social modulation rather than a social regulation? Interestingly, Zaki and Williams (2013) suggest the classification of social buffering as an interpersonal *modulation* process rather than *regulation*. They speculate that social buffering (defined as the mere presence of others) is better defined as an interpersonal modulation of emotions as it is more incidental. More specifically, one's emotional response is unsolicitedly modulated by someone present in the social context, and thus influenced in the earlier stage of the emotion-generative process. This is a useful reflection when attempting to differentiate, define and describe different (although highly intertwined) affective processes.

In the next section, I introduce social reappraisal as a cognitive emotion regulation strategy, a process which falls into Zaki and Williams' (2013) definition of interpersonal *regulation* as it represents a more active and controlled pursuit of a regulatory goal.

2.2.2.2 Social reappraisal

Cognitive reappraisal (Gross, 2015) consists of an explicit and controlled regulation strategy (Braunstein et al., 2017) involving the reassessment of a situation in a manner that changes its emotional impact (McRae & Gross, 2020).

In **Study IV,** we attempted to examine whether others' affective responses to a negative experience could regulate one's own affective response. One lab study previously showed that following a traumatic film, reading written testimonials downplaying the film reduced avoidance thoughts and memory characteristics (i.e. participants' sense of reliving the memory) during the following seven days (Takarangi et al., 2014). In **Study IV,** we added to this approach of examining how written comments modulate affective response following a trauma film by investigating its effect in a digital setting. In fact, one area where we are highly

exposed to what others think or feel is the digital world. In an online context, the exposure to pictures, films or audio content is very often accompanied by others' assessments.

The exposure to negative media content surrounding disasters and violence has been shown to predict an increase in PTSD symptoms and in physical health ailments (Silver et al., 2013). Furthermore, its cumulative exposure was found to increase risk of developing or prolonging acute stress-related symptoms (Garfin et al., 2015; Holman et al., 2014; Thompson et al., 2019). Notably, online we are exposed to both negative content as well as what others say of this content. In **Study IV** we hypothesized that seeing how others appraise online negative content influences how individuals up- or down-regulate their affective response related to the negative content. This process, which we defined as *social reappraisal* describes the process of how the social context regulates one's affective response through cognitive reassessment of the situation.

Next, I introduce social influences on the transfer of affective responses, which defines the way emotions "spread" from one person to another. The emotion regulation processes previously discussed may be part of the processes involved in the transfer of affective responses. However, transfer of affective responses between individuals will be regarded as a broader concept in the following section.

2.3 SOCIAL INFLUENCES ON THE TRANSFER OF AFFECTIVE RESPONSES

While experiencing the airplane turbulence, the reaction of a few passengers sitting in the front of the plane can spread to the rest of the passengers. This transfer of affective responses between individuals (also referred to "expressers" and "targets") is a process, which we examined in **Study III** of this thesis. Here, I discuss emotional contagion (e.g. Hatfield et al., 1994) and social appraisal (Manstead & Fischer, 2001), which are two (fairly entangled) processes of affective transfer.

2.3.1 Emotion contagion

As the name implies, emotion contagion suggests that emotions can be caught from one person by another (Hatfield et al., 1994). In the process of affect transfer through emotion contagion, the expresser's influence on a target's emotion is not deliberate (Peters & Kashima, 2015; Reeck et al., 2016). This process is assumed to take place very early in the emotion-generative process and to happen automatically without awareness of the object of the emotion by the target (Parkinson, 2011).

Investigating the influence of social networks in the spread of affects is highly clinically relevant. For example, longitudinal (population-based) examinations have provided evidence that phenomena such as loneliness (Cacioppo et al., 2009) and depression (Rosenquist et al., 2011) spread from one person to another across real-life social networks.

Such findings point out the need for interventions targeting certain population to reduce the spread of unpleasant emotions throughout social networks.

2.3.1.1 Is emotion contagion fully automatic?

In the primitive emotion contagion model (Hatfield et al., 1994), the mechanisms involved were defined as the results of a two-stage process in which the target 1) matches or mirrors someone's emotion expression (mimicry), leading them to 2) match the expresser's emotion (i.e. emotion transfer via interoceptive signals, also referred to bottom-up process). However, whether spontaneous mimicry leads to a congruent affective response (bottom-up process), or whether it is the congruence of affective response that is responsible for the congruent facial expressions (top-down process) is a central question (Peters & Kashima, 2015). In fact, recent studies pointed out that emotion contagion includes additional (correcting) mechanisms taking place in social contexts in which mimicry is blocked or attenuated because it does not serve a social purpose (e.g. when mimicry is not socially appropriate) (Wróbel & Imbir, 2019).

Emotion contagion is more likely to include an implicit interpretation, combining therefore both interoceptive and exteroceptive cues (Parkinson, 2020). For instance, in a diary study, asking participants to report on daily decisions involving others, Parkinson and Simons (2009) examined the transfer of emotions in everyday social life. According to their results, the emotion contagion process consists of how 1) others' emotions influence the audience's own emotion, which then 2) influences their appraisal. This suggests that through emotion contagion, the way we appraise an event is mediated by the change in our own emotion induced by others' affective response.

2.3.1.2 Digital emotion contagion

Importantly, direct contact (i.e. face-to-face interaction) is not essential for affect transfer to occur (Goldenberg & Gross, 2020), opening to a new field of digital emotion contagion research. In fact, as we spend more time on the internet, we are exposed to an increasing amount of positive and negative online content along with others' affective responses to this content. For example, during interactions on social media we are exposed to others' online behavior and reactions (e.g. ratings, likes, dislikes, reviews, comments). Such digital interactions affect our emotional states in the same way as face-to-face interaction, even though they are absent of nonverbal cues (e.g. facial expression, bodily posture; Herrando & Constantinides, 2021), supporting the idea that mimicry might not be necessary for emotion contagion to take place.

For instance, one (controversial) study manipulated the amount of emotional content Facebook users saw in their news feed and found that merely manipulating the number of

positive and negative posts viewed influenced, respectively, the number of positive and negative posts those users then made (Kramer et al., 2014). Another study using observational experiments demonstrated similar emotion contagion on Twitter where an over-exposure to negative versus positive tweets was followed by an increased posting of, respectively, a negative versus positive tweets (Ferrara & Yang, 2015). People predominantly share more negative (vs. positive) content online, regardless of whether the content is related to a negative or positive event, such as losing or winning a political election (Schöne et al., 2021). Additionally, anger seems to spread faster than joy, as angry tweets are more likely to spread through even weak social ties than joyful tweets (Fan et al., 2020). These results are consistent with classic research showing a "negativity bias" in attention, memory, and conformity (Rozin & Royzman, 2001) and support the need for further research on how negative content and information spread from one person to another online.

As we have seen the powerful influence of online information shaping evaluations of COVID-19 as either dangerous or harmless (Fuentes & Peterson, 2021; Haman, 2020), one central concept to our current digital experience is threat, more specifically, the online transmission of threat. In **Study III** we therefore asked whether the processes of affect transfer could also result in the social transmission of threat (i.e., evaluating events or stimuli as dangerous)? This idea is supported by a substantial literature on social learning (Olsson et al., 2020) indicating that it is psychologically efficient for people to learn to evaluate stimuli as threatening or safe from other people, rather than directly engaging with potentially threatening situations. In **Study III,** we were interested in the psychological processes that could explain online transmission of threat evaluations. Below, I introduce social appraisal, another way emotions are transferred from one individual to another.

2.3.2 Social appraisal

Social appraisal refers to the phenomenon in which the *interpretation* of others' emotion influences one's affective response (e.g. Lazarus, 1991). In fact, in addition to directly appraising what is happening around us, we also appraise objects and events on the basis of others' affective responses (Manstead & Fischer, 2001).

As opposed to the more implicit emotion contagion process described above, social appraisal is considered an intentional transmission of affect (Peters & Kashima, 2015). In this context, social appraisal does not simply include picking up on the "flavour" of someone else's feelings but also its intentionality. "Social appraisal involves an articulated inferential process in which people draw conclusions about the evaluative and interpretational implications of the other person's emotion" (Parkinson, 2011, p.435). As opposed to emotion contagion, social appraisal is assumed to apply in contexts in which the expresser and the target are oriented toward the same object or event (Parkinson, 2020). In this manner, the

process underlying social appraisal is presumed to be as followed, 1) the expresser's emotional response alters the target's appraisal, leading to 2) matching appraisal with the expresser, which in turn 3) induces changes in the affective response that may result in an alignment with the expresser's emotions (Parkinson, 2011; Parkinson & Simons, 2009).

One may wonder whether social appraisal is fully intentional. This *more* explicit and cognitive transfer for emotion is actually not presumed to be exclusively explicit and intentional. Using a lower level cueing process, assessment of our environment does not need to involve registering the expresser's specific object-directed emotion. The literature refers to the research on social referencing in early development and the classic visual cliff study in which infants relied on their mothers' positive or fear and negative facial expressions to guide their decision to cross a visual cliff or not (Sorce et al., 1985). A more recent example in adults showed that when exposed to a more anxious friend via a video, participants made less risky decisions (Parkinson et al., 2012).

In **Study III,** we examined the psychological processes that could explain online transmission of threat evaluations and its emotional influence. To do so we combined behavioral and computational modeling approaches to estimate the influence of others' online evaluations of negative pictures on participant's own evaluations and their concomitant emotional responses.

3 RESEARCH AIMS

The overall aim of this thesis was to advance the understanding of how social influences surrounding a negative experience can affect the formation, regulation and transfer of affective responses. The four studies included in this thesis attempted to examine specific aims related to these processes.

Study I aimed at testing whether physiological synchrony between a demonstrator and an observer during the learning phase of a dyadic vicarious learning paradigm can predict the strength of the observer's threat learning, later in the absence of the demonstrator.

Study II aimed at testing whether threat conditioning generates intrusive memories of neutral stimuli and to examine whether different social support interactions impact the expression of emotional memories.

Study III aimed at testing whether being exposed to others' online evaluations of whether pictures are threatening or safe influences the individuals' choice to label and share these pictures as threatening or safe, and influences their affective response to the pictures.

Study IV aimed at testing whether using the trauma film paradigm in a digital setting with minimum researcher guidance can increase negative mood and generate intrusive memories of the film, and to examine whether reading others' appraisals of the trauma film modulates individuals' affective responses to the film.

4 RESEARCH APPROACH AND CONSIDERATIONS

In the next pages, I start by describing the population we used in our studies. Then I describe how we operationalized, in each study, different kinds of social influences (face-to-face and online) surrounding different kinds of negative experiences (experimental analogues for aversive trauma experiences), and their impact on different kinds of affective responses (from physiological responses to self-reported measures).

4.1 RESEARCH PARTICIPANTS

All participants included in this thesis were identified as healthy individuals with no (self-reported) psychiatric disorders. Despite the negative nature of some of the stimuli used in the studies, we did not exclude at recruitment those who might have previously experienced trauma (in line with other studies in the field). Including participants with potential previous traumatic experience provided us with a better standing of the impact of trauma history and how it could influence outcome measures or possibly moderating the impact of our manipulations. As a safeguard measure and for ethical reasons, all participants were informed about the negative materials included in each study prior to signing up and again on the consent form at the beginning of the experiment. All participants were also informed that they could terminate their participation at any time with full compensation.

All participants in our lab studies (**Study I** and **II**, $n = 291$) gave their written informed consent for their participation by signing an informed consent form prior to participation. Afterwards, they also received oral debriefing and movie vouchers as compensation for their participation. All participants in our online studies (**Study III** and **IV**, $n = 388$) read a description of the study and the negative materials included in the study description and gave their consent by agreeing (i.e. ticking a checkbox) to a statement explicitly agreeing to participate. Online participants received a written debriefing and monetary compensation via the online recruitment platform.

4.2 OPERATIONALIZATION OF SOCIAL INFLUENCES

Here I describe how we operationalized social influences in our four studies, either face-to-face (**Study I** and **II**) or online (**Study III** and **IV)**. Below I define these operationalizations and propose their benefits and limitations in terms of their experimental aim and their ecological validity.

4.2.1 Face-to-face social influences

Study I and **II** consisted of experiments taking place in our laboratory at the Emotion Lab. In **Study I**, social influence was operationalized as the observation of another participant *during* threat acquisition (vicarious threat learning) and in **Study II** social influence was

operationalized as a short interaction (supportive, unsupportive or no interaction) with the experimenter *after* threat acquisition (Pavlovian threat conditioning).

In **Study I**, face-to-face social influence was operationalized as a (novel) dyadic vicarious threat learning paradigm. Such live settings were previously used (for ex. Berger, 1962) before more recently using a video recording of a demonstrator (Golkar et al., 2013, 2015, 2016; Lindström et al., 2019; Olsson & Phelps, 2007). Each dyads consisted of two participants (gender-matched) who did not already know each other prior to their participation. One participant was randomly assigned to start as the demonstrator undergoing a direct conditioning procedure. First, in the learning phase the *demonstrator* sat in front of a computer and watched two pictures repeatedly presented in random order on a computer screen, one followed by an uncomfortable but not painful shock (CS+) and the other one never followed by a shock (CS-). The other participant was assigned to be the *observer*, learning from the demonstrator's reactions to the presentation of the stimuli. The observer sat next to the demonstrator at an angle so that they could look at both the presentation on the computer screen as well as the demonstrator. In this way, the demonstrator learned the contingency between CS and US via direct experience, while the observer learned the contingency via observing the demonstrator's reaction to the shocks, that is, vicariously. Participants were informed that all communication between them was forbidden for the entire duration of the experiment.

Next, in the testing phase, the observer was informed that they would now view the same two CS and receive shocks to the same stimuli that they had observed the demonstrator previously receive shocks to. During this phase, the demonstrator was instructed to close their eyes and a screen was placed between the two participants, occluding the observers' view of the demonstrator to ensure that the observer would not be able to pick up any cues from the demonstrator. Unbeknownst to the observer, only the final CS+ presentation was actually followed by a shock. This final shock was given to ensure that the observers would consider the threat of shock credible in the rest of the experiment and avoid full extinction. This procedure / block was repeated one more time (same observer, same demonstrator but different CS).

After these two blocks, the roles were exchanged and the observer became the demonstrator and vice versa, for two additional blocks. The dyad set-up allowed us to examine the role of affective experience sharing in vicarious threat learning, as measured via physiological synchrony (i.e. skin conductance responses). The benefit of this role-switch half way through the experiment was that it allowed us to record more blocks from each recruited dyad, maximizing power for our planned analyses, yet stay in accordance with our ethics application not allowing us to expose the demonstrator to more than two phases of direct conditioning. The understandable limitation with this procedure was that becoming the

observer after being the demonstrator could contaminate their learning. However, additional analyses indicated no difference in learning between participants who began the experiment as observers and those who became observers in the second half of the experiment. Another limitation of live dyads was the low expression of the demonstrator during the learning phase. The demonstrator was aware that the observer would be observing them in order to learn the contingency between CS and US. Nevertheless, their facial and bodily expression of discomfort from the shocks was mild compared to the expression of discomfort from the demonstrator in studies using video recordings. Fortunately, this did not seem to have influenced vicarious learning as our findings showed that all participants did indeed learn.

In **Study II**, we developed a 3-4 min social support interaction between the experimenter and the participant. More specifically, social support was operationalized as two social support conditions (supportive social interaction versus unsupportive social interaction) providing two qualitatively distinct social interactions aimed to induce positive and negative social experiences, respectively. A third neutral condition was used as control group (no social interaction). The social support interaction manipulation took place right after threat acquisition and before threat extinction and consisted of an experimenter (who had not yet interacted with the participant) entering the room where the participant sat and administering one of the three conditions (random assignment).

These interactions consisted of minimal verbal exchange and were designed to provide informational (provision of information that can be used to guide and advice), instrumental (provision of concrete aid through material goods or physical assistance) and emotional support (verbal and nonverbal communication of empathy and care; Hogan et al., 2002). We were interested in testing an interaction similar to the one occurring between strangers after a traumatic experience (e.g. between a patient and medical staff in the waiting room at the emergency department), therefore we chose an in-person interaction with a stranger as opposed to an interaction with a social support figure (e.g. friend or family member) or a support reminder (e.g. photos). In fact, the objective of using a social support interaction with minimal verbal exchange was to aid the development of a supportive interaction given by laypeople, immediately after a negative experience, such as a trauma.

In the supportive social interaction condition, the participant received (1) informational support by being informed about what was going on during the break and how long the break would last; (2) instrumental support by being offered a glass of water, being informed that the door of the experimental room would be left open to let fresh air into the room during the break, and at the end of the break, being informed about the possibility of pressing a button to continue the experiment when they felt ready; (3) emotional support by asking them if they felt alright while having a hand on their shoulder; keeping eye contact with them and

smiling to them; asking them if they felt good to continue the experiment. This condition aimed to induce a positive state. The unsupportive social interaction aimed to induce a negative state and consisted of (1) the second experimenter not providing the participant any information about what was happening during the break; did not answer any questions the participant might have; the participant was informed that the time they would spend in the room was unclear; (2) a dirty glass of water not intended for the participant was put next to them by the second experimenter without explanation; (3) the door of the room was left open without any explanation, the second experimenter walked in and out the room several times without talking directly to them or having eye contact. Finally, in the neutral control condition (no social interaction), the participant received, by the second experimenter, a commercial furniture catalogue to read, which was taken back at the end of the 4 min break. The experimenter entering the room without having social interaction with the participant provided an experimental design control for the presence of someone in the supportive social interaction and unsupportive social interaction conditions. The furniture catalogue was meant to equalize the level of distraction between the conditions during the break, whilst controlling for the neutral and low arousing content (furniture).

A limitation of using such impersonal interaction is that despite the fact that participants rated the supportive interaction as significantly more supportive than the unsupportive interaction or than the control group, its effect might not have been strong enough to translate into differences in emotional responses. In fact, recent brain imaging studies compared brain activations of holding hands with a partner, a stranger or not holding hands with anyone during exposure to emotional visual stimuli (Kraus et al., 2019, 2020). Their findings indicated that holding hands with a partner reduced emotion-related neural activity compared to holding hands with a stranger or being alone, suggesting that our support interaction might not have been powerful enough maybe due to the fact that it was provided by a stranger. An important difference is that in our study, the social support interaction manipulation took place after and not during the negative experience, compared to other experimental studies in the literature investigating the buffering effect of social support on negative experience (e.g. Roberts et al., 2015). Only few experimental studies have investigated social support interactions after a negative experience. To our knowledge, only two studies have specifically looked at the influence of social support interactions on the development of intrusive memories after viewing a traumatic film, one with social support by a romantic partner (negative versus positive reactions; Woodward & Gayle Beck, 2017) and the other one using video recording of a stranger giving (positive, negative or no support; Pruitt & Zoellner, 2008). These studies showed that more negative interactions may result in more intrusive memories of aversive footage. One assumption is that in our study, the way we operationalized unsupportive interaction might not have been too out of context for an experimental setting. More specifically, having an experimenter not providing any

information and coming in and out of the room might have been perceived strange and maybe irritating and not perceived as supportive, but might not have had the same effect of a negative interactions directly invalidating the participants' experience.

As per our overall aim, both **Study I** and **Study II** examined the impact of different face-to-face social influences on the formation and regulation of affective responses surrounding negative experiences. An increase experience sharing via physiological synchrony during vicarious threat learning improved threat learning, in line with the literature showing the effect of social cues on the formation of affective responses (Golkar et al., 2013; Haaker et al., 2017). Different social support interactions with a stranger after threat learning did however not modulate affective response. This suggests that this specific kind of interaction might not modulate the processes underlying memory consolidation.

4.2.2 Online social influences

Study III and **IV** consisted of online experiments in which online social influences consisted of seeing other people's online behavior (i.e. clicking choices, **Study III**) or reading others' comments, **Study IV**).

Study III was run on Amazon's Mechanical Turk (MTurk) platform, consisted of two online sub-studies. Online social influence was operationalized as participants being exposed to how 100 other MTurk workers (peers) previously categorized pictures as "threatening" or "safe" to share with others. The numbers of peers' "threatening" and "safe" categorizations were randomly generated for each picture but always added to a 100.

We were interested in online spread of information by looking at the impact of others' online behavior on one's affective response. In sub-study 1, the experiment was as follows. First, participants indicated how distressed each picture made them feel (0 = *not at all distressed*, 100 = *very distressed*). Secondly, we aimed to resemble the exposure to others' online behavior (i.e. clicking thumbs up or thumbs down on social media), therefore, while seeing how peers previously categorized each picture, participants were asked to themselves categorize the pictures as "threatening" or "safe" by clicking on either a red X or a green checkmark, respectively. We instructed participants to categorize a picture as "threatening" if it "is likely to cause emotional distress to others" and to categorize it as "safe" if it "is not likely to cause emotional distress to others". When clicking on either symbol, participants saw the number of previous categorizations increase by 1 for their chosen category in order to lead participants to believe that their own categorizations would add to the full set of answers that would be used in subsequent studies. In order to increase similarity with social media platforms, participants were asked to click a "share" button to share their categorization for future participants to view.

To estimate how peers' evaluations influenced participants' categorizations of the picture as safe or threatening we used both regression and computational approaches. The regression approach estimated a conformity score quantifying the strength of the relationship between the number of peers who categorized the pictures as threatening and the participant's tendency to categorize picture as threatening. However, this approach could not dissociate the peers' threat and safety influence. We therefore developed an exploratory computational model in order to estimate how strongly participants were influenced by both threat and safety information. This computational approach allowed us to estimate two free parameters; θ (Theta), measuring how strongly participants incorporate peers' threat categorizations into their own categorizations and φ (Phi), measuring how strongly participants incorporate peers' safety categorizations into their own categorizations. By comparing models with and without a combination of these parameters enabled us to estimate the best fitting model of participants' own categorizations.

Next, we were interested in whether conforming to peers' categorizations of the pictures would lead participants to change their affective response regarding these pictures. Therefore, in sub-study 2 we replicated the tasks in stub-study 1 and added a second distress rating, allowing us to estimate whether others' threat/safety evaluations influenced their feelings of distress. We used a regression approach to estimate an emotion influence score for each participant indicating how strongly peers' categorizations was related to participants' second distress ratings, after controlling for their initial distress ratings. Finally, we hypothesized that the degree to which participants incorporate peers' information in the categorization task related to how strongly peers' information influences their emotional responses to the pictures, and therefore also examined the relationship between this emotion influence score and both θ and φ.

One limitation of how we operationalized social influences in this study is that we used an online paradigm with a high degree of experimental control with a simple dual-choice forced task, rather than using social media data. On the one hand, being able to control and manipulate peers' threat and safety evaluations, we decreased the ecological validity of our paradigm. On the other hand, such paradigm helped us estimate the weight of participants' own distress and others' categorization in their decision. Being able to estimate participants' emotion change from a baseline to post manipulation is more challenging when using social media data (Goldenberg & Gross, 2020), which is a strength of our study.

Another limitation is that the design of this paradigm did not allow us to draw any conclusion on the specific underlying mechanism promoting the change of affective responses. More specifically, whether more top-down or bottom-up processes are involved in the social influences captured in **Study III** was not directly measures. However, our findings indicate

that participants' affective response (measured by their initial distress rating) was modified following the exposure to others' threat/safety evaluations. Logically, based on the nature of our design (i.e. the chronological order of our measures) we assume that, this change is due to the process of social appraisal. As introduced earlier (Parkinson, 2011; Parkinson & Simons, 2009), the process of social appraisal assumes that the expresser's affective response alters the target's appraisal, which changes the target's appraisal, inducing a change in the target's own affective response. Therefore, we assume that a top-down process such as social appraisal took place, rather than the more bottom-up process of emotion contagion. Importantly, this is a theoretical assumption, as this study was not designed to examine such differences.

Study IV consisted of an online study carried out on Prolific (Prolific, London, UK) and aimed to resemble both the exposure to negative visual content online as well as to others' emotional reaction to this content. In this study, participants first took part of an online version in the trauma film paradigm (described in section 4.3.2). Next, participants were randomly assigned either to one of two experimental groups or a control group. Here, social influence was operationalized as participants being asked to read 20 comments from previous participants ostensibly sharing how they appraised the trauma film. These comments were either positive (positive group), negative (negative group) or participants were not exposed to any comments, instead they were asked to wait for 20s for the rest of the study to upload (control group). Overall, these comments aimed to facilitate coping versus rumination, decrease versus amplify feelings of distress / fear / anger, normalize feelings versus boost negativity, and finally, increase clarity and rationality versus ambiguity and worry about the future. Examples of positive comments include "*It's just a safety film to help protect children, so although I think it's normal to feel upset watching this, I can easily remember it's not real!*" and "*These movies are made to shock you on purpose, I understand why they are helpful as safety movies*!" These positive comments attempted to promote the emotion regulation technique of putting things into a broader perspective (Schartau et al., 2009). Examples of negative comments include "*This is for real, children are dying ALL THE TIME on the road!*!" and "*These movies are shocking, I don't understand why they show them to the general public*". As a manipulation check, participants were asked to answer a single item regarding the valence of the comments they read (between-subjects measure), from 0 = *very negative* to 10 = *very positive*. We examined the effect of this social manipulation on affective response measured by change in negative mood post trauma film to post manipulation and intrusive memories of the trauma film during the subsequent seven days. We predicted that the exposure to others' appraisal would lead participants to reappraise the content of the film as a way to regulate the negative affects generated by the trauma film. More specifically, we predicted that, across groups, negative mood would increase from before to after

watching the trauma film. We also predicted that the total number of intrusive memories reported during the subsequent seven days after film viewing would be greater than zero (only examined in the control group).

Study IV has similar limitation as the ones mentioned for **Study III**. For instance, in **Study IV** we also attempted to examine online social influences on affective responses by using a very controlled paradigm rather than social media data. Reading comments on social media usually include writing something yourself or even having a discussion with others, therefore the social influences online might be more interactive than the task used in the **Study IV**. Another limitation is the fact that in **Study IV**, we suggest that the change in negative mood following the task of reading others' appraisals is related to reappraisal of the content of the film as an attempt to regulate their affective response to the film. However, this paradigm did not include an estimation of participants' emotion regulation strategy. We are therefore unable to make a strong conclusion about what the processes are and can only assume that our findings capture social appraisal of negative content.

As per our overall aim, both **Study III** and **Study IV** have examined the impact of different online social influences on the regulation and transfer of affective responses surrounding negative experiences. Nevertheless, an important limitation is that neither of these studies allow us to draw conclusion about the exact mechanism underlying the changes we reported. This is further discussed in the Discussion section of this thesis.

4.3 OPERATIONALIZATION OF NEGATIVE EXPERIENCES

Here I describe how we operationalized negative experiences in our four studies using controlled experimental approaches, in laboratory settings using electric shocks and online using negative pictures or film. Below I describe the different stimuli and paradigms we used and suggest both their benefits and limitations in terms of their experimental aim and their ecological validity.

4.3.1 Threat conditioning paradigm

In **Study I** and **II**, the negative experiences consisted of receiving uncomfortable but not painful electric shocks to the lower arm as part of threat conditioning paradigms. Participants underwent a vicarious threat learning in **Study I** and a direct threat conditioning with neutral stimuli as CS and electric shocks as US in **Study II**. In the next few paragraphs, I first introduce the materials we used (conditioned stimuli and electrical shock procedure) before describing the paradigms as a whole.

4.3.1.1 Condition stimuli (CS)

In **Study I**, eight geometrical shapes (e.g. a square, a circle, a hexagon) of different colors were used as CS. For each participant, two of the eight shapes were randomly selected and assigned as CS+ or CS-.

In **Study II**, eight pictures of neutral objects from the international affective picture system (IAPS) database (Lang et al., 2008) were selected as CS. The pictures were previously rated as being low arousal (*M* = 3.05, *SD* = 2.01), neutral valence (*M* = 5.00, *SD* = 1.32) and neutral dominance (*M* = 6.04, *SD* = 1.95) (Lang et al., 2008) and depicted a neutral object, for example a tray of buttons or a blue mug on a wooden table. Neutral and non-traumatic picture stimuli were purposely selected in order to make sure they were not intrinsically intrusive. For each participant, two of the eight pictures were randomly selected and assigned as CS.

4.3.1.2 Electric shock procedure

In both **Study I** and **II,** we used electric shocks as aversive stimuli (US), a common procedure in threat learning paradigms (Olsson et al., 2005; Phelps & LeDoux, 2005). Before starting the experiment, shock-electrodes were placed on participants' lower arms. The electric shocks were delivered by a STM200 Biopac Systems with a 100 ms DC-pulse (Biopac System, Inc., Goleta, CA, USA).

In **Study I**, the shock electrodes were attached to the arm of each participant closest to the stimulus monitor to maximize visibility of the arm to the other participant, meaning that depending on what roles they started with (observer or demonstrator), the shock-electrodes were on their right or left lower arms. In **Study II**, the shock-electrodes were always attached to participants' right lower arm.

Each participant went through an individual work-up procedure to calibrate the appropriate level of electric shocks using an ascending staircase procedure. Participants were instructed to choose a level of stimulation which they experienced as "uncomfortable, but not painful". In **Study I**, both participants underwent shock calibration in front of each other prior to the first learning phase. This is unlike previous video-based studies in which observers had to guess what shocks would be like from the (exaggerated) reactions of the demonstrators, here the observers knew the shock level they set for themselves and they had an accurate idea of the threat the shocks posed.

4.3.1.3 Threat conditioning paradigms and procedures

Threat conditioning paradigms begin with a learning phase (also called an acquisition phase) during which the participants learn the association between the CS and US, that is one of

two stimuli is followed by a shock (CS+) and the other one is not (CS-). The CS are presented on a computer screen 6 times for 6s each and separated by an inter-trial interval (ITI, a gray screen) of 10-16s. Four of the six CS+ presentations were immediately followed by an electric shock (i.e. 75% reinforcement). In **Study I,** participants underwent a dyadic vicarious threat learning, meaning that for the observer the learning phase took place via the observation of the demonstrator's reaction to the presentation of the CS, while the demonstrator had direct exposure to the CS and US. In **Study II,** participants underwent a direct threat conditioning paradigm meaning that during the learning phase participants had direct exposure to the CS and US.

Next, is the test phase (also called extinction phase), consisting of the presentation of non-reinforced CS presentations (i.e. CS+ is not followed by US). As the participants are unaware that they will not receive any shocks, it is expected that during the first few CS presentations participants have a stronger skin conductance responses (SCR) at the presentation of CS+ compared to the presentation of CS-. Then, they slowly learn the new information that CS+ does not predict the US anymore. The number of presentations of the non-reinforced CS during the test phase depends on whether or not the experimental procedure needs the participants to experience full extinction. In **Study I**, the extinction phase contained seven presentations of each stimulus, and only the last CS+ presentation was followed by a shock. This last shock during extinction is not common in traditional vicarious threat learning paradigms, but was necessary in this setting in order to ensure that the observer would consider the threat of shock credible in the next phase of the experiment. In **Study II**, however, the extinction phase contained nine presentations in order to ensure full extinction of the learned threat.

In **Study II** we included a reinstatement phase which took place seven days after threat conditioning and consisted of the presentation of a gray screen and three unexpected electric shocks followed by 9 non-reinforced presentations of the two CS presented during the prior threat conditioning procedure. Reinstatement is a procedure that tests the process of return of learned threat after a time delay, serving as an experimental model for clinical relapse (Lonsdorf et al., 2017). Because of the three unexpected US, a recall of the CR (i.e. a higher SCR to CS+ compared to CS-) is expected. In our study however, results showed an over-arousal response to both CS. We assume that this might be due to the specificity of our paradigm. We believe that we could have had a re-extinction phase prior to reinstatement, which is a procedure in which the participant is first presented with non-reinforced CS *before* the three unexpected electric shocks. Because of the absence of this re-extinction phase, our findings cannot distinguish the potential effect of spontaneous recovery from reinstatement. Furthermore, our study is the first study including a measure of intrusive memories between extinction and reinstatement of learned threat. Being asked

to report potential intrusive memories of the CS after extinction is most likely to have affected the return of learned threat measured during our reinstatement procedure.

A benefit of using threat conditioning paradigms as an experimental analogue of stressful events, such as in **Study II**, is the relative simplicity of the procedure as compared to the complexity of real-world aversive experiences. Another benefit is the use of benign stimuli (i.e. neutral pictures) and the use of a mild aversive experience (uncomfortable but not painful electric shocks) as such stimuli minimize the potential influence of participants' differences in preexisting aversions (e.g. when using fear-relevant pictures) and emotional learning history (e.g. when using images of blood, violence and injuries). Nevertheless, these factors may also pose certain limitations to using threat conditioning paradigms, that is, the use of standardized aversive stimuli that have very little resemblance to real-life stressful events. In fact, different adaptations of this paradigm have been developed using complex and naturalistic stimuli. One example is the conditioned-intrusion paradigm (Wegerer et al., 2013), in which neutral sounds were used as CS and paired with aversive film clips (US). A more recent study (Franke et al., 2021) used neutral faces as CS and aversive films as US to investigate intrusive visual, auditory, thought and/or feelings CS and US. Considering these different threat conditioning paradigms, the benefits and limitations of using a standard threat conditioning paradigm, as we did in **Study I** and **Study II,** comes back to the main goal and the optimal balance between experimental control and ecological validity of the specific experiment.

4.3.2 Negative pictures

In **Study III**, we used mildly to very negative pictures as experimental analogues for still visual pictures shared online. Sixty pictures were drawn from the Open Affective Standardized Image Set (OASIS; Kurdi et al., 2017) and contained gruesome scenarios with a diverse range of themes (i.e. objects, humans, animals, or scenes). These pictures were selected based on normative valence ratings (i.e., the degree of positive or negative affect that the pictures evoked; Kurdi et al., 2017) determined on a 7-point Likert scale (ranging from 1 = *Very negative* to 7 = *Very positive*). These picture valence ratings were found to be reliable and consistent across gender groups (Kurdi et al., 2017).

The benefit of using OASIS pictures was the fact that they were already rated which allowed us to not only control their content (i.e. themes) but also their valence. The reason for selecting a variety of pictures that ranged from mildly negative to very negative is because we wanted to focus on perceptions of threat and safety in pictures that are ambiguously threatening. Had we selected pictures that were not negative enough then participants might not have believed peers' threat categorizations and if the pictures were too negative, they would not believe peers' safety categorizations. This is one limitation of **Study III**. Given this

choice of stimuli, along with the fact that the number of peers' threat and safety categorization were randomized, might have led participants to doubt that the categorizations were truly given by others (e.g., a fairly neutral picture being categorized as threatening by a high number of peers), which would affect their tendency to conform. However, our results show that participants' behavior systematically changed to resemble peers' behavior, suggesting that participants believed the ratings enough to be influenced by them.

4.3.3 The trauma film paradigm

In **Study IV**, we used the trauma film paradigm as an experimental analogue for exposure to aversive visual content online. The trauma film consists of 12 min of scenes including distressing content. The footage used in our lab experiments is typically taken from the public domain, such as car crash seatbelt safety films (Holmes & Bourne, 2008; James et al., 2016). This paradigm provides an experimental model by which to study reactions to witnessing psychological trauma (James et al., 2016) and its sequelae. The trauma film paradigm has been used to examine cognitive processes underlying the development or maintenance of symptoms of PTSD such as intrusive memories (Holmes et al., 2009; James et al., 2015; Lau-Zhu et al., 2019). It has been used to identify pre-existing vulnerabilities affecting reaction to traumatic events (Clark et al., 2015; Laposa & Alden, 2008), and to help the development of clinical intervention techniques and procedures to help to reduce the occurrence of intrusive memories of trauma (Iyadurai et al., 2018; Kanstrup et al., 2021).

The basic methodology in studies using the trauma film paradigm has been developed by Holmes and colleagues (Holmes et al., 2004; Holmes & Bourne, 2008; James et al., 2016) and goes back to early experimental psychopathology studies by Horowitz (1968) and Lazarus and colleagues (1962). In this thesis, the methodology was adapted to a digital format and pilot tested on 41 participants before collecting the full sample size. Here, I describe the paradigm used in **Study IV**. At the start of the experiment, specific instructions were given to the participants to promote protocol completion, that is, making sure that the participants watch the whole film without pausing or being distracted. Because data collection took place online, and in order to increase participants' compliance, such instructions were first given via a three minute zoom call with the experimenter. Within this call the experimenter could verify that the participants (who were remote, typically in their own home) had an appropriate setting for viewing the trauma film (i.e. using a computer and headphones, alone in the room with closed curtains and lights off, no distraction, cellphone off, able to do the study in one go). Specific instructions were also given on *how* to watch the traumatic film (i.e. immerse themselves in the film, pay close attention, not look away or shut eyes, imagine being at the scene as a real bystander and being personally affected by

these events). These instructions were followed by check questions to insure participants' understanding of the instructions.

Right before viewing the trauma film participants filled in a measure of state negative mood. Participants were then asked to view the film with the sound on and in full screen to optimize immersion. Directly after the film participants reported a second measure of state negative mood to assess the impact of film viewing, along with other measures to check compliance with any experimental manipulations (i.e. how much attention they paid to the movie, how often they looked away, how relevant the film was for them, if they had seen parts of the film before and how distressing they found the film). Next, our social reappraisal manipulation took place. Finally, the participants were instructed on what an intrusive memory is and how to report them in the electronic intrusive memory diary.

One benefit of the trauma film paradigm is that it has repeatedly been found to generate the expected affective responses. Using such a well-documented paradigm facilitated its implementation in a digital setting. Furthermore, because the film clips included in the traumatic film were made for TV use, they were ideally adapted for viewing on a computer screen and illustrated the type of negative images that participants' would most like be exposed to online. One limitation of this paradigm is the fact that the content of the film is not personally related to the individual participant. This does resemble exposure to random news feeds online but might impact the strength of the affective responses to the film. One strategy we employed was giving clear instructions to the participants as to watch the trauma film by really immersing and involving themselves in the film, by imagining they were at the scene as a real bystander witnessing the event unfold in front of their own eyes and imagining these events were happening to someone they knew and affected them personally.

4.4 OPERATIONALIZATION OF AFFECTIVE RESPONSES

Here I describe how we operationalized affective responses. In our four studies, we assessed individuals' physiological arousal and self-reported measures as readouts of affective responses following a negative experience. Below I will define how we collected, processed and evaluated these measures, along with their benefits and limitations in terms of their experimental aim and their ecological validity.

4.4.1 Skin conductance responses

In **Study I** and **II**, which took place in our laboratory, affective responses were operationalized as autonomic arousal measured through skin conductance. Using threat conditioning paradigms, we recorded participants' SCR as an index of threat learning.

SCR indicates the phasic increase in skin conductance in response to the presentation of stimuli. To measure SCR, two SCR Biopac EL507 electrodermal activity (EDA) electrodes were attached to the participant's index and middle finger of the hand that did not hold shock electrodes. SCR was recorded by a Biopac MP150 system (Biopac System, Inc., Goleta, CA, USA). The collected raw SCR was then processed in the AcqKnowledge 4.1 software (Biopac System, Inc.) and filtered with a low- and then high-pass filter to remove possible artifacts and tonic competent of the signal (Boucsein, 2012). Following protocols (Haaker et al., 2017), SCR were established by measuring the base-to-peak (TTP) amplitude in the largest phasic signal in a time window between 0.5 s and 4.5 s following stimulus onset. As opposed to the first phasic signal, which can be interpreted as the reaction to the onset, and the second signal, which can be interpreted as the reaction to the anticipatory response to the shocks, the largest signal captures the whole process. All SCR with an amplitude below 0.02 µS, or no SCR within the time window mentioned above were set to 0 (Dunsmoor et al., 2015; Golkar et al., 2012). SCRs were squared root transformed to normalize the distribution prior to analyses. For each participant we inferred their CR by subtracting their SCRs to the presentation of the CS+ with their SCRs to the CS-.

The benefit of using measures of skin conductance is that it is a non-intrusive measure and it is the most commonly used index of CR. Unlike self-report, such a physiological measure of threat learning has the advantage of not being biased. Nevertheless, there are some considerations to take into account when using SCR (which are summarized in Lonsdorf et al., 2017). SCR can, for example, be elicited by other stimuli than the CS and US such as other measures taken during the experiment (e.g. startle probe or ratings). Another consideration is that the programming of the experiment, more specifically the timing between the presentations of the stimuli must take into account both the delay of the response as well as time for the skin conductance to go back to baseline. Another consideration is the fact that SCR is sensitive to repeated presentation of the same stimuli, meaning that longer experiments or across-days experiments might be affected by habituation.

4.4.2 Self-reported negative affects

In **Study III** and **IV**, which took place online, affective responses were measured using self-reported measures of negative affect.

4.4.2.1 Feeling of distress

In **Study III**, we measured self-reported feeling of distress an index for emotional impact of the exposure to negative pictures online. Here is how participants' feeling of distress was measured: first, at the beginning of both sub-studies we asked participants to indicate how distressed 60 negative pictures made them feel on a VAS scale from 0 = *not at all distressed*

to 100 = *very distressed*, which allowed us to estimate an initial level of negative affect towards the picture stimuli. This initial distress rating was also used in our analyses when trying to predict participants' categorizations of pictures as either threatening or safe while controlling for participants' initial distress ratings. Then, only in sub-study 2, participants answered a second time how distressed the same negative pictures made them feel *after* they saw previous participants' threat/safety evaluations and categorized the pictures themselves. This follow-up measure allowed us to estimate a potential shift in how the picture stimuli were perceived based on how previous participants ostensibly categorized them.

A benefit of using a single-item measure of distress was that it was easy and quick for participants to answer for each of the 60 picture stimuli, which was important in order to have enough data points for our computational modeling approach. One disadvantage was that the term distress could be a subjective concept, which might overlap with other concepts such as stress and anxiety. A measure containing several measures of negative emotion could have given us a more objective measure of negative affect but as mentioned above, additional ratings would have increased the length of an already long experiment.

4.4.2.2 Negative mood

In **Study IV**, we measured the participant's negative mood as an index for change in negative affect throughout the experiment. Negative mood was measured at baseline, after viewing the trauma film and again after our social reappraisal manipulation.

A persistent negative mood state following exposure to a traumatic event is common and can result in "experience[ing] markedly diminished interest or participation in previously enjoyed, feeling detached or estranged from other people, or a persistent inability to feel positive emotions" (DSM-V, American Psychiatric Association, 2013, p.275). In fact, experimental work using the trauma film paradigm predicts an increase of negative mood from pre to post watching the film. Clark et al. (2015) indicated that having a low negative mood change from pre to post trauma film was associated with the absence of intrusive memories. In **Study IV**, negative mood was assessed by computing a negative mood score calculated by summing up 6 visual analogue scales (VAS) assessing how sad, fearful, anxious, depressed, horrified and hopeless participants feel at the moment, from 0 = *not at all* to 100 = *extremely*. Such measure of negative mood has been used in all studies using the trauma film to estimate the impact of the film on participants (James et al., 2016), however, some of them included measures of positive emotions or a shorter version including only (e.g. sadness, depression and hopelessness; Lau-Zhu et al., 2019).

There are a few benefits and limitations in using this measure of negative mood. One benefit is that it has been used in previous studies using a similar paradigm, which allows the

comparison of results between studies. Another benefit is that based on previous studies, we knew the expected effect and therefore we could evaluate the feasibility of our novel digital paradigm. Nevertheless, one limitation of this measure is that theoretically, a measure of sadness, fear, anxiety, depression, horror and hopelessness may better refer to a measure of negative affect rather than negative mood as it combines both emotions (intense and short term affects directed at a specific object) such as sadness, fear, anxiety and horror, as well as more diffused affects such as depression and hopelessness. Rightfully, by calculating the sum of the six subscale, this measure does reflect a more general negative diffuse affects (i.e. mood) but might benefit from the use of the umbrella term of negative affect instead.

4.4.3 Intrusive memories

In **Studies II** and **IV** affective responses were measured as numbers of intrusive memories of neutral picture stimuli (**Study II**) or a traumatic film (**Study IV**). In the next few paragraphs, I will introduce how we defined intrusive memories in our studies followed by a more throughout discussion on the measure of affective association to intrusive memories. Then I describe how we collected the intrusive memories data using an electronic diary survey and how we processed this data. I finish this section by discussing potential limitations and benefits of using this measure of intrusive memories.

4.4.3.1 Defining intrusive memories

Intrusive memories are common after a traumatic event and typically take the form of vivid visual images of scenes of the event (Ehlers et al., 2004; Hoppe et al., 2022; Singh, Garate, et al., 2022). They occur in the form of involuntary recollection (rather than deliberate recall), that is, spring into mind without being expected. The term intrusive refers to their involuntary and unwanted nature. Clinically, in their more extreme form, intrusive memories can impact one's mental health and day-to-day functioning (Iyadurai et al., 2019). Although for most people intrusive memories of a traumatic event subside over time, if they persist their maintenance makes them a central symptom of anxiety-related disorders or disorders after trauma such as PTSD (DSM-V, American Psychiatric Association, 2013). Furthermore, intrusive memories are referred as a driver of other PTSD symptoms and are key targets for intervention (Iyadurai et al., 2019). This raises the importance of developing interventions targeting intrusive memories using laboratory based research to generate new approaches (Singh et al., 2020).

As done in previous studies (Holmes & Mathews, 2010; Iyadurai et al., 2019), intrusive memories were defined to the participants as mental images of the film that might pop into their mind, without them wanting to, throughout their daily life. Intrusive memories are not verbal thoughts or deliberately choosing to think about the stimuli.

4.4.3.2 Affective association to intrusive memories

Intrusive memories can vary in emotional valence (from negative to positive), however, in our work the types of affective association related to the intrusive memories is not central to our research (Espinosa et al., 2022; Holmes et al., 2005; Iyadurai et al., 2019; Singh et al., 2020) as we know intrusive memories can also occur in even apparently positive states such as mania in bipolar disorder (Ivins et al., 2014). In our current line of work, our interest lies in their occurrence in the form of involuntary recollection, i.e. without being expected. The central line of enquiry in our work is therefore to reduce the number of times intrusive memories reoccur (rather than the cognitive or emotional content of such intrusions). In fact, recent linguistic analysis of intrusive memories soon after trauma (both in the clinic and lab) indicates that intrusive memories primarily contain words related to space and sensory features, yet few words related to cognitions and emotions (Hoppe et al., 2022; Singh, Garate, et al., 2022). In **Study II**, in order to examine potential difference between groups in affective association to intrusive memories we applied for an amendment of our ethic application to add to the intrusive memory diary a measure of how distressing (0 = n*ot distressing at all* to 10 = *very distressing*) and vivid (0 = *not vivid at all: it was not clear* to 10 = *very vivid: it was as clear as actual vision*) each intrusive memory was. The amendment was accepted only half way through data collection therefore data was collected only for the last third of the participants and was therefore not included in the published manuscript. Based on reviewers comments and interest in an effective measure of intrusive memories during the publication procedures for **Study II**, we included a measure of distress and vividness in **Study IV**.

4.4.3.3 Electronic intrusive memory diary survey

In both **Study II** and **IV** participants were asked to report potential intrusive memories they might have during the seven days following their participation using an electronic diary survey, which was sent to them every morning. Instructions on how to report them were given using animated instruction videos (Singh, Lau-Zhu & Holmes, In Prep). The instructions and the protocol for use of the intrusive memory diary were adapted for electronic format using a Qualtrics survey (Qualtrics, Provo, UT) based on earlier studies using an electronic diary (Espinosa et al., 2022; Singh et al., 2021; Singh, Ahmed Pihlgren, et al., 2022).

In **Study II**, we carried out a one-year follow-up survey to investigate whether intrusive memories may persist over time and examine potential predictors underlying reasons why some might continue to have intrusive memories. Unpleasant stimuli (IAPS pictures) have been shown to be better recalled and more likely to generate intrusive memories up to a year after exposure (Bywaters et al., 2004) (Bywaters, Andrade, & Turpin, 2004) and

subjective experience related to conditioning has been shown to be maintained up to a year after conditioning (Wiggert et al., 2017). In our one-year follow-up, we compared participants reporting intrusive memories only during the seven days after conditioning to participants reporting to continuous intrusive memories during the year after conditioning on potential predictors such as pre-existing vulnerabilities (i.e. self-reported measures reported at Day 1 of lab experiment) and memory performance (measured at one year follow-up).

4.4.3.4 Data processing

In **Study II** intrusive memories included in our analyses were of the two neutral picture stimuli (CS) which were randomly selected for each participant (e.g. a blue mug or a clock) and in **Study IV** intrusive memories were generated by the trauma film (e.g. child texting while crossing the road). In order to verify that the intrusive memory reported in the diary survey were related to the content of the stimuli participants were exposed to, we asked participants to write a brief description (free report) of each of their intrusive memory (e.g. "the blue mug" or "the little girl at the side of the road being hit by a car"). Only intrusive memories that could be matched with the stimuli were included. At the end of data collection, the experimenter attempted to match each intrusive memory with the stimuli. Next, these intrusive memories were inspected to estimate whether they were indeed described as visual and/or auditory intrusions. When such estimation could not be made, two experimenters evaluated them independently, and any disagreements were discussed. Only intrusive memories that were matched with the stimuli and described as visual and/or auditory were included in the analyses.

One benefit of using this measure of intrusive memory is that two decades of both experimental and clinical research have allowed the development of a well-designed paradigm along with very clear instructions assuring the participants' understanding of what an intrusive memory is and how to report them. The video instruction materials used in **Study IV** were recently developed by Singh, Lau-Zhu & Holmes (In Prep) in order to enable remote data collection during the COVID-19 restriction but originally with the goal of developing new innovative and remote interventions.

In both studies, a majority of participants (78-100%) filled out the seven days intrusive memory diary surveys showing a high level of compliance and indicating another strength of this measure despite the requirement to be completed multiple times. As opposed to the previous paper version of the diary, the electronic form allowed for better tracking of the participants' compliance and allowed us to send reminders if needed.

One limitation is the fact that by simply instructing participants on what an intrusive memory is and asking them to report them, we might prime them to notice and report more intrusive memories. As we were interested in comparisons in the number of intrusive memories

between our experimental groups (i.e. predicting an increase or decrease of intrusive memories between the control group and the other experimental groups), this is not an issue in our studies.

4.5 PRE-EXISTING VULNERABILITIES

Here, I report the psychological measures we included in our studies. In fact, throughout this thesis, one of our aims was to explore potential pre-existing psychological vulnerabilities that might impact our outcome variables or our manipulations. We therefore used self-reported questionnaires filled out by the participants at the beginning or at the end of their participation in our experiments.

We collected self-reported questionnaires measuring inter-individual differences that might modulate the effect of social influences on our outcome variables such as learning in **Study I** and **Study II** and/or the effect of our manipulations in **Study II** and **IV**. These questionnaires consisted of the Interpersonal Reactivity Index (IRI) measuring perspective taking, fantasy, empathic concern and personal distress, the Balanced Emotional Empathy Test (BEES; Mehrabian, 1996) measuring emotional empathy, or the Interpersonal Regulation Questionnaire (IRQ; Williams et al., 2018) measuring individual's tendency to recruit social resources to regulate their emotions assessed individual differences.

Additionally, we collected self-reported questionnaires measuring pre-existing vulnerabilities that have previously been associated with sensitivity to traumatic stress reactions (Clark et al., 2015; Laposa & Alden, 2008). We collected measures of anxiety with the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983), general use of mental imagery with the Spontaneous Use of Imagery Scale (SUIS; Nelis et al., 2014), a self-reported measure of depressive symptoms using the Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001) and the number of previous traumatic experiences was calculated using the Traumatic Experience Questionnaire (TEQ; Crawford et al., 2008).

Additional questionnaires were included as exploratory measures, which we reported as collected for transparency, but did not include them in the main analyses. For instance, in **Study III** we included measures such as the Support for Free Speech Scale (SFS; Alvarez & Kemmelmeier, 2018), the Generalized Anxiety Disorder Scale (GAD7; Spitzer et al., 2006), the Posttraumatic Stress Disorder Checklist (PCL-5) and the Patient-Health Questionnaire (PHQ-9; Kroenke et al., 2001). on the last electronic diary survey (at day 7) of **Study IV** we included exploratory measures based on previous publications using the trauma film paradigm. These included a retrospective rating of intrusive memory during the past seven days (Hackmann et al., 2004; Michael et al., 2005; Speckens et al., 2006) measuring how many times participants experienced unwanted memories (from 1 = *never* to 7 = *many times a day*) and different characteristics of these intrusive memories (e.g.

distressing, from 0 = *not at all* to 100 = *very strongly*). It also included the Impact of Event Scale - Revised (IES-R; M. Horowitz et al., 1979) containing the eight items referring to intrusive memories (from 0 = *not at all* to 4 = *extremely*) including three subscales assessing 1) frequency of intrusive memories, 2) avoidance behavior and 3) hyperarousal. As was done by James et al. (2015) we reformulated the questions by referring to the movie instead of the event. Next, a self-rated measure of functioning associated with intrusive memories (Iyadurai et al., 2019) was assessed with a single item on the degree to which the potential intrusive memories had affected participants' everyday functioning (0 = *no adverse impact* to 10 = *extreme impact*). And finally, a self-rated sleep rating including two items about participants' sleep since their participation (Luik et al., 2019), assessing the extent to which participants were bothered by poor sleep after their participation in the study (from 1 = *not at all* to 5 = *very much*) and how many nights participants had problems with poor sleep.

4.6 ETHICAL CONSIDERATIONS

All studies in this thesis received ethical approval by the Regional Ethical Review Board in Stockholm. Nevertheless, the process of writing the ethics applications demanded important discussions and the development of strict safeguarding measures to minimize the impact of our experimental paradigms on participants' long-term wellbeing. Here I will discuss ethical considerations regarding the materials and the social manipulations used in the studies included in this thesis.

4.6.1 Recruitment

One ethical consideration is the inclusion of participants who might have had previously experienced a trauma. In line with previous studies from our lab, we did not exclude individuals that might have experienced trauma. Considerations of risks included the lack of a harmful side effects specific to those with a trauma history in previous studies. Further, given that 90% of people will experience an event that can be defined as traumatic in their lifetime, removing all participants who had experienced some form of trauma would significantly skew both the sample as well as the representativeness of the results for precisely those groups to whom they may be most relevant. We developed a thorough step-by-step recruitment procedure ensuring that individuals who signed up our studies were fully aware of the distressing nature of the experiment and type of content to which they would view. We also reminded them at the beginning of their participation in the consent form that they were allowed to terminate their participation at any time, without any consequences and with full compensation. Identical to previous lab experiments, participants included in **Study IV** first answered first a pre-screening questionnaire in order to only allow individuals with a score lower than 8 on two Likert scales assessing sensitivity for blood and tendency to fainting (0 = *not at all* to 10 = *extremely true*).

4.6.2 Paradigms

One ethical consideration are the paradigms we used in order to generate an increase of stress responses in the participants. Importantly, all participants were informed of the negative materials prior to them signing up. They then received written and oral (in lab experiments) description of the negative content on the consent form at the beginning of the experiment and were informed that they could terminate their participation at any time with full compensation.

4.6.2.1 Threat conditioning and electric shocks

One ethical consideration of using a conditioning paradigm is, that in **Study II** we showed that the picture of neutral objects used in such threat conditioning paradigm can pop into the participants' head mostly during the following week, but also up to a year later (Espinosa et al., 2022). It is therefore important to take this new information into consideration when using this paradigm. Further investigation would be needed to estimate the extent to which this paradigm, which has been extensively used, leads participants to have intrusive memories of the stimuli used. Thankfully, our study showed that these intrusions were only moderately distressing (e.g. at one year follow-up, M = 1.10, SD = 0.91, range 0.50–4.5 on a scale from 1 to 9).

In **Study I** and **II,** we used electric shocks. At the start of the experiments, participants choose an uncomfortable but not painful level of electric shocks specific to them using a very rigorous protocol. Furthermore, although participants were deceived into believing they were going to receive many shocks, they only received a few shocks (a total of ten in **Study I** and four in **Study II**). There are no known side effects of electric shocks delivered by the Biopac Systems (Biopac System, Inc., Goleta, CA, USA) apart from, in very rare cases, a slight irritation of the skin. The benefit of using electric shocks compared to using a US such as visual stimuli of violent scenes is that shocks' levels are chosen individually and are only mildly uncomfortable. Furthermore, although electric shocks generate a stressful experience that is not similar to experiences in real life, such stimuli help control for potential preexisting aversions and emotional learning history, as compared to pictures of snake or spiders, or images of interpersonal violence.

4.6.2.2 Trauma film paradigm

In **Study IV,** we used the trauma film paradigm containing aversive images that have been shown to generate an increase of negative mood and intrusive memories. The ethical question is clear, is it worth using such a paradigm knowing its impact on participants' wellbeing? Looking at the wide range of studies, the knowledge gained from using this paradigm is significant. Thankfully, experts in the field have published a thorough review on

the use of the trauma film paradigm (James et al., 2016) illustrating its benefit in both understanding the basic mechanisms underlying symptom development, as well as providing suggestions for future use. Such studies are now in clinical translation and poised to be helping patients after trauma and those with PTSD (Iyadurai et al., 2018; Kanstrup et al., 2021; Kessler et al., 2018) with current randomized controlled trails underway (Ramineni et al., 2022). As mentioned earlier, strict safeguarding measures to inform the participants and minimize the impact of the trauma film on participants' long term wellbeing have also been established. The pitfall of using an experimental analogue of negative experiences to carry on group comparisons is that affective responses need to be strong enough to run these statistical analyses. In fact, anecdotal discussions with fellow researchers has brought to my attention that using a less stressful situation (e.g. The Trier Social Stress Test, Allen et al., 2017) often leads to floor effect, making it impossible to estimate the potential effect of an experimental manipulation.

4.6.3 Social manipulations

Another ethical consideration is the social manipulations used in our different studies. More specifically, participants were randomly assigned to receiving or being exposed to different types of positive, negative or no social influences. The benefit of testing social influences of different valences experimentally is that such an investigation can inarguably not be done in clinical settings, yet understanding the potential detrimental effects of negative social influences is equally important to investigating the potential benefit of positive social influences. In our studies, although positive and negative valence conditions were significantly different from the control group (and from each other), our negative manipulation was not rated as extremely negative (**Study II**, unsupportive interaction $M = 4.22$, $SD = 1.15$ on a scale from 0 to 9, 0 meaning very low perceived support; **Study IV**, negative comments $M = 2.12$, $SD = .20$ on a scale from 0 to 10, 0 meaning very negative).

Regardless, exposing participants to negative social influence can be problematic and therefore must be soundly considered. Additionally, these manipulations entail some deception, that is, participants were told that they were exposed to what previous participants reported. These were in fact fictitious. Some level of deception in psychological experiments is common, however careful debriefing including detailed explanation of the deception and why it was needed to deceive them is important and was given to the participants at the end of each study.

5 SUMMARY OF ALL STUDIES

5.1 STUDY I: PHYSIOLOGICAL SYNCHRONY PREDICTS OBSERVATIONAL THREAT LEARNING IN HUMANS

5.1.1 Key questions

In this lab study, we examined two questions. First, using dyads of participants, we asked whether physiological synchrony between a demonstrator and an observer could serve to predict the strength of vicariously acquired conditioned threat responses. Second, we asked whether individuals' self-reported trait empathy predicted both vicarious threat learning as well as the effects of physiological synchrony.

5.1.2 Key methods

A total 139 participants composed of 69 gender-matched demonstrator-observer dyads (45 female) participated in a vicarious threat learning paradigm. Sample size was established using a power simulation, which indicated that 65 dyads would provide 90% power to assess an effect size of 0.04 (in $\sqrt{\mu S}$) for the target interaction between a our measure of synchrony and CS. Participants were recruited via advertisement on the Karolinska Institutet Psychology division's recruitment website.

Skin conductance responses were measured as index of learning and computed to establish synchronization of demonstrator-observer's physiological responses during learning. Using the interpersonal reactivity index (IRI), self-rated empathy was measured as a potential predictor of vicarious threat learning.

5.1.3 Key results

First, as predicted and illustrated in Figure 1, an increased physiological synchronization of the observer with the demonstrator during the learning phase was shown to result in improved CS differentiation during the test phase, showing a critical and previously undocumented link between demonstrator-observer synchrony and vicarious threat learning.

Second, contrary to prediction, self-reported empathy was not found to be related to physiological coupling, suggesting that the momentary physiological coupling between observers and demonstrators occurs beyond participants' introspective abilities and that synchrony might constitute a more fundamental feature of empathic learning than captured by self-reported measures.

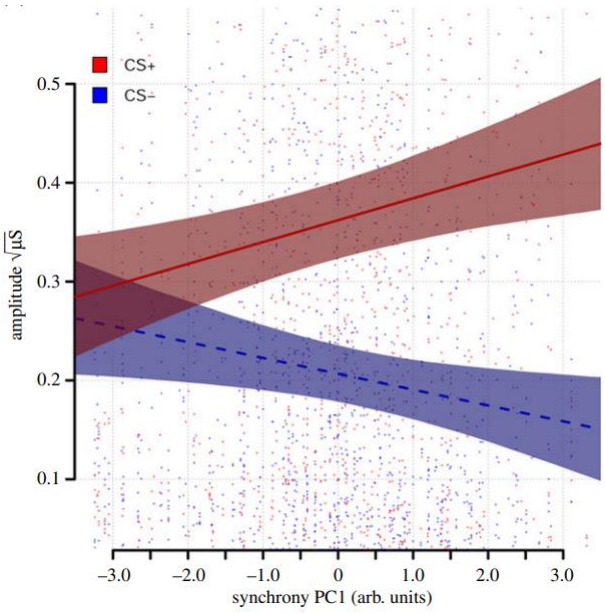

Figure 1. Synchrony component positively predicts CS differentiation. Posterior prediction of the observer's CS+ (red, solid line) and CS− (blue, dashed line) responses during the testing phase, as a function of synchrony during the learning phase. Points represent individual data points from separate CS presentations. Shaded region indicates 95% posterior predictive interval.

5.2 STUDY II: PAVLOVIAN THREAT CONDITIONING CAN GENERATE INTRUSIVE MEMORIES THAT PERSIST OVER TIME

5.2.1 Key questions

In this lab study, we examined four questions. First, we asked whether a Pavlovian threat conditioning paradigm with pictures of neutral objects as CS and uncomfortable but not painful electric shocks as US, could generate intrusive memories of the CS during the subsequent seven days and whether these intrusive memories would persist over time. Second, we asked whether the total number of intrusive memories of CS+ and CS- during the following week, or having intrusive memories at all, would be driven by pre-existing vulnerabilities that have previously been associated with sensitivity to traumatic stress reactions. Third, we asked whether different social support interactions (supportive social interaction, unsupportive social interaction or no social interaction) after acquisition of learned threat influenced the expression of the emotional memory measured by skin conductance responses (SCR; during extinction and during a reinstatement test procedure seven days after conditioning), and number of intrusive memories of the CS during seven days following conditioning. And fourth, we ran a one-year follow-up survey and asked whether intrusive memories may persist over time and investigated both potential predictors underlying reasons why some participants might continue to have intrusive memories as well as memory performance.

5.2.2 Key methods

A total of 91 participants (47 female) were recruited via advertisement on the Karolinska Institutet Psychology division's recruitment website. Sample size was determined based on

estimated known effects of threat conditioning, extinction and interference of consolidation in healthy participants (Duits et al., 2015; Kindt & Soeter, 2013). Based on an estimated effect size of d = 0.40, a total of 28 participants per group (n = 83) were estimated as needed to obtain 90% power to detect a moderate effect of the interference of social support on threat response during extinction (α = 0.05).

Participants underwent a direct threat conditioning paradigm composed of an acquisition phase, extinction phase and reinstatement phase seven days later. Between the acquisition and extinction phases participants were randomized to experience a supportive social interaction, unsupportive social interaction or no social interaction. During the seven days following conditioning, participants were asked to complete an online daily intrusive memory diary including a measure of the number of intrusive memories of the picture stimuli (CS) they have had during a specific time frame. Approximately 12 months later, 59 participants (36 female) answered a one-year follow-up electronic survey.

5.2.3 Key results

First, as predicted and shown in Figure 2, threat conditioning with pictures of neutral objects and electric shocks generated intrusive memories of the conditioned stimuli during the subsequent seven days, with more CS+ than CS- intrusive memories. This result adds to an emerging body of evidence showing that associative processes contribute to the formation of intrusive memories (Franke et al., 2021; Miedl et al., 2020; Wegerer et al., 2013).

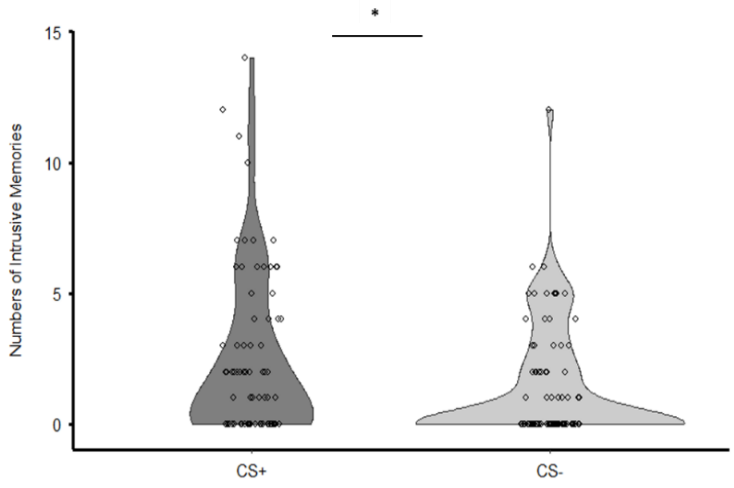

Figure 2. Violin Plot of Number of Intrusive Memories for the CS+ and the CS- Reported over Seven Days in the Diary. Significant difference between the total number of intrusive memories for CS+ and CS-, across conditions combined. The dots illustrate individual data points for CS+ and CS- intrusive memories. *p < .05

Moreover, these findings highlight the advantage of using benign stimuli (e.g. a clock) and mild aversive experience (uncomfortable but not painful electric shocks) to investigate the

intrusive image-based aspect of threat memories while minimizing the influence of individual differences in preexisting aversions and emotional learning history.

Second, our results showed that anxiety was linked to a greater number of intrusive memories of the CS-. This suggests that these participants displayed a generalized imaged-based threat response to the safe stimulus and/or an impaired ability to inhibit image-based threat response to the safety cue.

Third, contrary to our predictions, we found that different social support did neither influence participants' physiological responses (i.e. during extinction and reinstatement; Figure 3b and 3c) nor the number of intrusive memories (Figure 4).

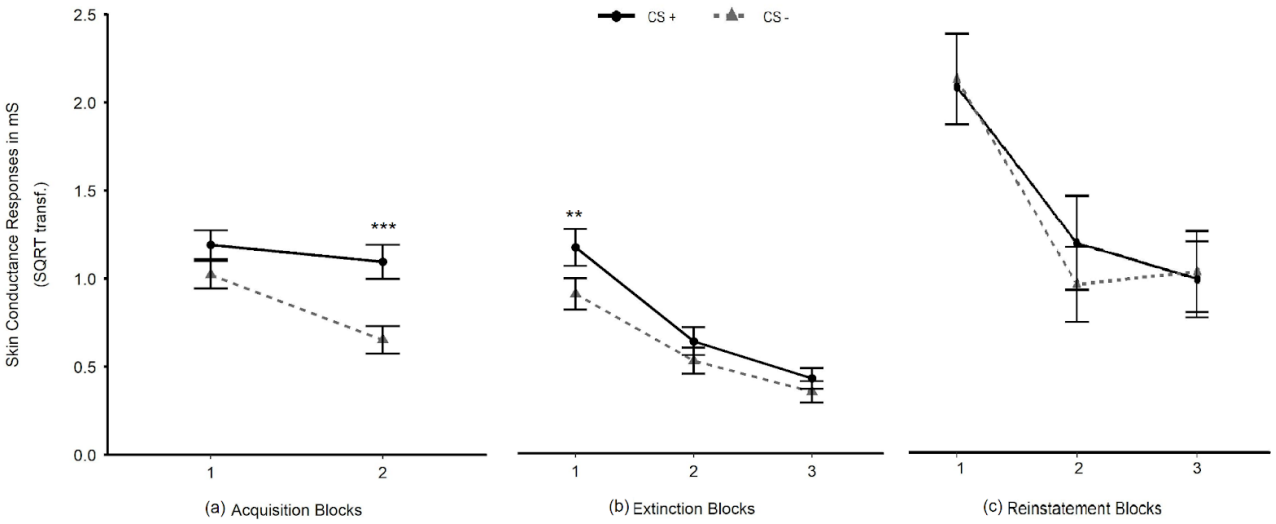

Figure 3. Block by Block SCR for CS+ and CS- during (a) Acquisition, (b) Extinction and (c) Reinstatement of Threat. A block consists of the mean of three trials. (a) Indicates a learned threat response illustrated by a stronger SCR for CS + than CS- at block 2. (b) Indicates an extinction of threat response illustrated by a stronger SCR for CS + than CS- at block 1 and a non-significant difference in SCR between CS+ and CS- at block 2 and 3. (c) Indicates a return of threat for both CS, illustrated by the increase of SCR between the block 3 of extinction and the block 1 of reinstatement. No significant differences between the social support interaction conditions were found in neither of the experimental phases. Error bars represent ±1 SEM. $^{**}p < .01$, $^{***}p < .001$.

As shown in Figure 4, our results showed that unsupportive social interaction resulted in a relative difference between the number of CS+ and CS- intrusive memories, suggesting that an unsupportive social experience could enhance the consolidation of visual threat memory. Follow-up analyses using differential scores (CS+ minus CS-) indicated that this difference was not significantly larger in the unsupportive social interaction group compared to the other two groups, meaning that this result must be interpreted with caution.

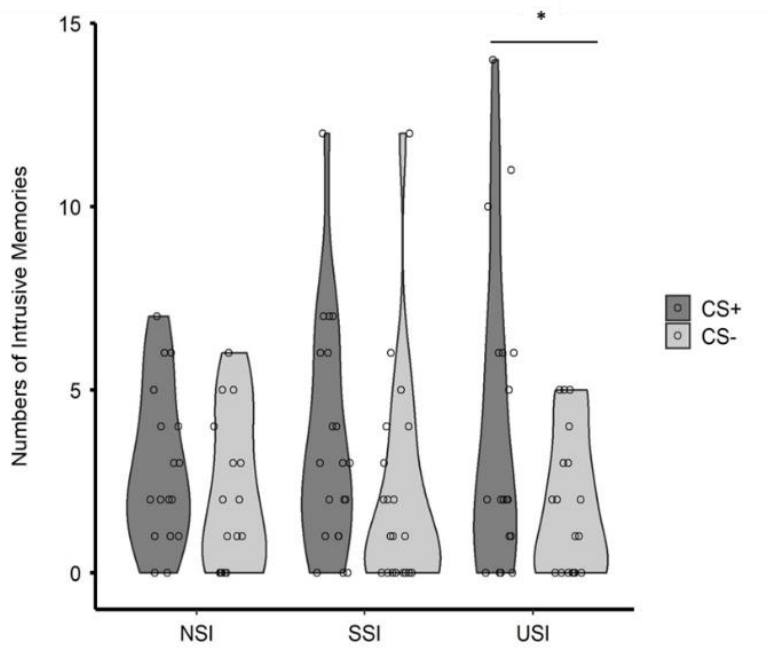

Figure 4. Violin Plot of Social Support Conditions and CS Indicating a Nested Effect on Intrusive Memories. As compared to control condition (no social interaction, NSI), supportive social interaction (SSI) did not differ in number of intrusive memories for CS+ and CS-. Unsupportive social interaction (USI) showed a significant difference between CS+ and CS- intrusive memories. The dots illustrate individual data points for CS+ and CS- intrusive memories. *$p < .05$

Fourth, the one-year follow-up indicated that intrusive memories of the CS can persist over time. Specifically, 50% of the participants who responded to our electronic survey and who had intrusive memories during the lab experiment reported that they continued to have intrusive memories during the following year. Our results also indicated that in our sample, continuous intrusive memories were related to higher trait anxiety at baseline and greater number of previous traumatic experiences.

Contrary to our predictions, our results showed no relationship between continuing to have intrusive memories and better memory performances of the two picture stimuli or of the CS+ but these results are consistent with the pattern of dissociation between intrusive memories and recognition performance and with the notion of multiple memory systems.

5.3 STUDY III: SOCIAL TRANSMISSION OF THREAT EVALUATIONS AND FEELINGS OF DISTRESS

5.3.1 Key questions

This study consisted of two online sub-studies. We asked four questions: First, we asked whether choosing to label pictures as threatening or safe is influenced by seeing peers' threat/safety evaluations. Second, we tested a computational model of the way these peers' evaluations might drive participants' decision-making. Third, we asked whether peers' threat evaluations more strongly influenced one's own evaluation than peers' safety evaluations. Fourth, we asked whether seeing peers' threat/safety evaluations modulated one's feelings of distress.

5.3.2 Key methods

This study consisted of two pre-registered online studies with a total of 218 participants recruited from the Amazon's Mechanical Turk (MTurk) platform. Sample size for each sub-study was established using power analysis based on estimated effect sizes produced by a pilot study showing that obtaining 80% power to replicate the smallest hypothesized effect (d = 0.39) would require 54 participants. Due to the risk for unusable data collected on MTurk, we decided, prior to initiating data collection, to increase sample size to about 100 individuals, which would give us a power of 95% for that effect size.

Sub-study 1 (n = 103) included two phases. First, participants indicated how distressed pictures made them feel, and second, they categorized these pictures as threatening or safe for others to see, while seeing how previous participants ostensibly categorized these pictures. In sub-study 2 (n = 115) participants completed the same two phases as in sub-study 1, followed by a third phase in which participants answered a follow-up distress rating for each picture which provided a second measure of participants' affective response to the pictures, enabling us to estimate changes in affective responses after being exposed to peers' categorizations.

5.3.3 Key results

First, our results in both sub-study 1 and 2 showed that as predicted individuals integrated peers' evaluations with their own. Second, in line with out hypothesis, our computational model indicated that the categorization of pictures as threatening emerges from integrating both one's own distress ratings and peers' evaluations. Third, contrary to prediction, participants did not integrate peer threat evaluations into their own evaluations *more strongly* than peer safety evaluations.

Fourth, sub-study 2 showed that, as predicted, integrating peers' evaluations into one's own threatening or safe categorization of a picture leads one to shift their feeling of distress. Notably, as shown in Figure 5, this effect was related to how *safety* information was integrated. Specifically, how strongly one incorporated peers' safety information into one's own evaluations was linked to how strongly the feeling of distress was influenced.

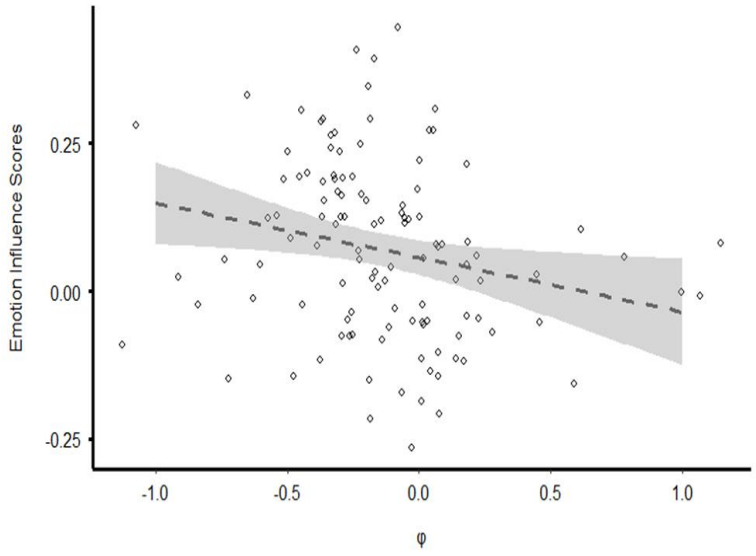

Figure 5. Correlation Between Emotion Influence Scores and φ. Significant correlation between emotion influence scores and φ (Phi) in sub-Study 2, indicating that those who more strongly incorporate peers' safety evaluations tend to be more emotionally influenced. Negative φ indicate that participants were more likely to categorize the picture as "safe" when more peers rated it "safe". Positive φ indicate that participants were more likely to categorize the picture as "threatening" when more peers rated it "safe".

5.4 STUDY IV: READING OTHERS' SOCIAL APPRAISALS AFTER VIEWING AN AVERSIVE FILM ONLINE IMPACTS MOOD BUT NOT INTRUSIVE MEMORIES

5.4.1 Key questions

In this online study, we examined two questions: First, we asked whether using the trauma film paradigm in an online setting could increase negative mood and generate intrusive memories of the film in a remote and less controlled environment with minimum researcher guidance (feasibility question). Second, we asked whether reading (fictitious) previous participants' appraisals of the online trauma film modulated individuals' affective responses to the film, as measured by changes in negative mood and the number of intrusive memories reported during the following seven days (effect of experimental manipulation question).

5.4.2 Key methods

After joining a 3 min zoom call with a researcher to verifying that the participant had an appropriate setting for completing the experiment (digital guidance), followed by baseline questionnaires, participants watched a 12 min trauma film consisting of distressing content. Next, participants were randomly assigned to one of three groups of the online social reappraisal manipulation (controls, reading positive comments or reading negative comments). Negative mood was measured both right before and right after watching the film, as well as after the social reappraisal manipulation. Finally, for the following seven days participants received an electronic diary survey every morning in which to record intrusive memories and rate their vividness and distress.

5.4.3 Key results

First, our results indicated that, as predicted, the remote online trauma film paradigm generated the expected affective responses, in line with recent in-lab experiments. More specifically, all participants experienced an increase of negative mood from pre to post trauma film, and a majority of them had intrusive memories during the following seven days, (Table 1, Figure 6), albeit an somewhat lower mean number (for the control group) compared to previous lab studies.

Table 1. Negative Mood Scores and Number of Intrusive Memories, Split by Social Reappraisal Groups (*n* = 170)

							Group comparisons					
	Control Group (n = 56)		**Positive Comments (n = 56)**		**Negative Comments (n = 58)**		***C* vs. *P***		***C* vs. *N***		***P* vs. *N***	
	Mean	SD	Mean	SD	Mean	SD	*b*	*t*	*b*	*t*	*b*	*t*
Negative mood												
Pre film	9.08	10.43	6.39	8.13	9.96	9.74	-2.69	-1.50	.88	.49	-3.58	-2.01
Post film	25.20	14.72	19.20	11.74	24.18	12.32	-3.31	-1.48	-2.07	-.93	-4.98	-2.04
Post social reappraisal	22.11	15.95	12.70	10.70	21.54	13.32	-6.75	-3.04**	-1.45	-.66	-8.85	-3,50**
Number of intrusive memories	3.98	.52	3.91	.52	3.66	.44	-.02	-.11	-.06	-.34	.18	.28

Note: *C* = control group, *P* = positive comments, *N* = negative comments. ** $p < .01$

Second, as shown in Table 1 and illustrated in Figure 6, reading positive comments after the trauma film improved individuals' mood to a greater extent than reading negative or no comments. Contrary to prediction, reading negative comments did not increase negative mood compared to controls.

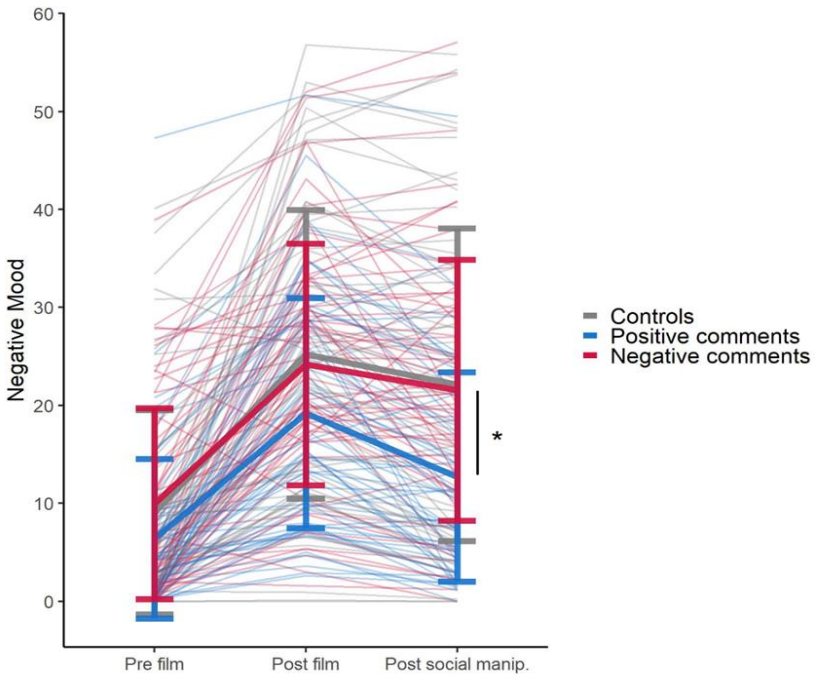

Figure 6. Line Plot illustrating Changes in Negative Mood Across the Three Time Points, by Group. No significant differences between groups were found pre-randomization (i.e., pre-film baseline, post-film). After the social reappraisal manipulation, participants who read positive (fictitious) comments from others about the film reported significantly lower negative mood, compared to participants who did not read any comments (controls) and those who read negative comments. *$p < .05$

Finally, as shown in Figure 7, contrary to prediction, social reappraisal did not modulate the number of intrusive memories.

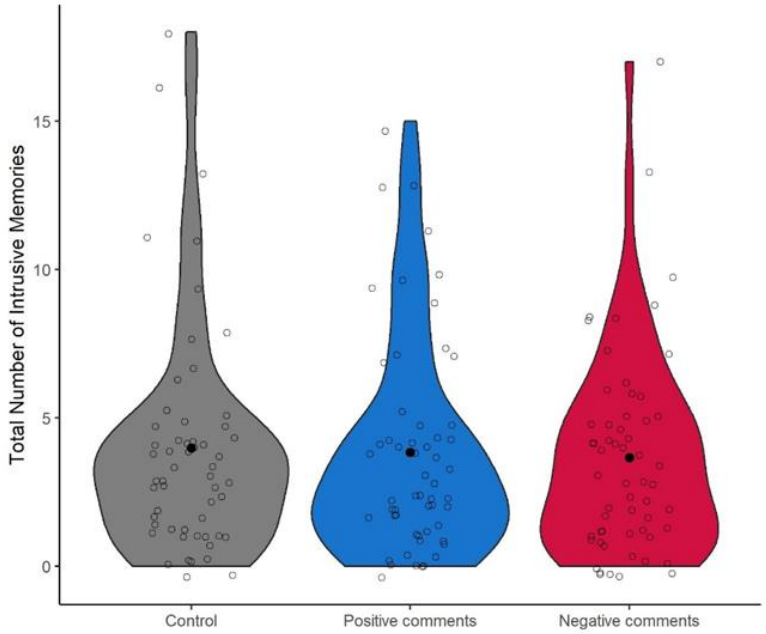

Figure 7. Violin Plots illustrating the Total Number of Intrusive Memories in the 7seven days Daily Diary by Group. Controls, *M* = 3.98, *SD* =.52; Positive, *M* = 3.91, *SD* = .52; Negative, *M* = 3.66, *SD* =.44. Circles represent individual data points, black dots indicate means per group, violins indicate the density of the data for each variable.

6 DISCUSSION

As social human beings, social ties are important protective factors for our mental and physical health. Therefore, it is important to investigate the ways we influence each other in the formation, regulation and transfer of affective responses to our environment, especially surrounding negative experiences. All four studies in this thesis aimed to examine psychological processes involved in the formation, regulation and transfer of affective responses using experimental approaches to investigate the development and maintenance of symptoms of anxiety-related disorders and PTSD. In the upcoming section, I will discuss the specific contribution of each of our studies in reaching this thesis' goal followed by a more general discussion on the general implications and limitations of these studies.

6.1 SUMMARY OF MAIN FINDINGS

6.1.1 Social influences on the *formation* of affective responses?

Vicarious threat conditioning is a paradigm allowing the investigation of (among others) the formation of affective responses via observation. Using video recordings, vicarious learning has been thoroughly researched, from its neural to its computational mechanisms (Andreas Olsson et al., 2020).

In **Study I,** we used dyads to examine the role of affective experience sharing in vicarious threat learning, as measured via synchrony of skin conductance responses between the observer and the demonstrator. Our results showed that the physiological synchronization of the observer with the demonstrator during the learning phase predicted the strength of the learning during the test phase, i.e. stronger CS+/CS- differentiation. Importantly, creating pseudo-dyads based on randomly pairing participants, we demonstrated that synchrony between observer and demonstrator was not only due to participants seeing the same stimuli, but indeed related to the specific dyads.

Our results support the involvement of social influences on the formation of affective responses via experience sharing. In fact, we argue that synchronization of physiological arousal during threat learning might be due to the observer mirroring the demonstrator's autonomic nervous system trajectories in parallel to the demonstrator's direct experience.

Contrary to prediction, self-reported empathy was not found to be related to physiological coupling. More specifically, the interpersonal reactivity index (IRI) which is a well-validated self-reported measure of trait empathy, did not predict vicarious threat learning and was not related to physiological synchrony. This finding suggests that affective experience sharing

measured via physiological synchrony is probably more related to experience sharing rather than individuals' tendency to imagine and experience the feelings and experiences of others (i.e. empathizing).

One potential reason that empathy was not found to be involved in physiological synchrony is the particular method used in our paradigm, including the instructions given to our participants. Empathy "refers to the way in which people can come to "feel" another person's emotion through an understanding of this person's circumstances" (Peters & Kashima, 2015, *p*.5) and is a process in which the *object* of the target's affective response (e.g. the observer) and the expresser's affective response (e.g. the demonstrator) are expected to be dissimilar (Peters & Kashima, 2015). More specifically, based on Peters and Kashima's (2015) notion of empathy, the object of the emotion of the expresser is irrelevant for the target, instead the target focuses on the expresser's wellbeing. In **Study I** however, the object of the emotion of the demonstrator was not irrelevant to the observer as it provided information related to the CS-US association that they were instructed to learn. A previous study using a video-recording vicarious threat learning paradigm asked participants to pay attention to the demonstrator's discomfort (empathic appraisal instructions) and showed that such empathic appraisal increased learning (Olsson et al., 2016). Moreover, they showed that this effect was driven by individuals with high trait empathy. In **Study I**, no such instructions were made, in fact we explicitly instructed the participants to learn the CS-US association via observation, which might have directed the observer's attention to both the demonstrator's expressions to the US and the CS-US association, attuning the role of empathic sharing in this particular setting.

6.1.2 Social influences on the *regulation* of affective responses?

In **Study II** and **IV,** we examined face-to-face and online social influences on the regulation of affective responses.

The buffering effect of social support on the effect of stress on health has been substantially endorsed (Ditzen & Heinrichs, 2014). In **Study II,** we attempted to experimentally model situations in which support interactions occur *after* a negative experience, trying to test whether such interaction would modulate affective responses (i.e. physiological responses and number of intrusive memories during seven days). Specifically, different social support interactions after threat learning did not modulate participants' physiological responses during extinction and reinstatement. Furthermore, compared to no social interaction, supportive social interaction did not decrease and unsupportive social interaction did not increase the number of intrusive memories. These findings suggest that such social interactions taking place after threat learning might not modulate acquired threat, which was in contrast with our expectations. This could be further examined by testing a different

operationalization of supportive social interaction following threat learning, for example using romantic partner such as in Woodward & Gayle Beck (2017)

One finding from **Study II** was that unsupportive social interactions resulted in a larger difference between the number of CS+ and CS- intrusive memories as compared to the no social support condition. This could suggest that an unsupportive interaction could have led to a stronger consolidation of visual threat memory following conditioning, causing more involuntary image-based conditioned threat responses. However, follow-up analyses indicated that this difference was not significantly larger in the unsupportive social interaction group compared to the other two groups, meaning that this result must be interpreted with caution. Further investigation would be necessary before any substantive conclusions can be made. Testing a replication of **Study II** may be important to inform us of the validity of these findings. Moreover, including a re-extinction phase to the procedure of return of fear which was missing in our study, could inform on whether the effect of unsupportive social interaction on intrusive memories could be detected in the physiological measures a week after threat conditioning.

In **Study IV** we used a novel digital protocol of the trauma film paradigm in order to investigate whether reading others' appraisal of the film could modulate individuals' affective responses to the film, as measured by changes in negative mood and the number of intrusive memories reported during the following seven days. Previous research has shown that reading testimonials from previous participants following a traumatic film modulates both the memory of the film as well as the frequency of analogue PTSD symptoms (Takarangi et al., 2014). In our study, we examined whether *online* social influences would modulate affective responses. As predicted, our results showed that after reading others' positive reaction to the film, individuals' negative mood would improve to a greater extent than after reading others' negative reaction or when not exposed to any reactions. Interestingly, in opposite to our predictions, reading negative comments did not increase negative mood compared to controls. One possible explanation for this effect could be that the negative comments only validated individuals' appraisal and that no negative reappraisal took place. Assuming that that people's strive to reach positive affect, reading negative comments may have simply been ignored, thereby producing levels of negative mood similar to those seen in the control group. Another assumption could be that reading negative comments from strangers online is very common and maybe as a protective mechanism, individuals did not integrate others' assessment into their own.

Contrary to our predictions, reappraisal via reading positive or negative comments did not impact the subsequent number of intrusive memories consolidation of the trauma film. In a previous study, healthy participants were trained to use cognitive reappraisal techniques to modulate the number of intrusive memories generated by the trauma film paradigm and their

results showed that participants who received positive reappraisal training had fewer intrusive memories of the film and lower avoidance and hyperarousal compared to those who received negative reappraisal training (Woud et al., 2012). This suggests that the passive reappraisal task used in our study might be enough to promote regulation of negative mood but not effective enough to modulate further expression of memory.

Importantly, due to the lack of evidence, we can only speculate that it is based on others' positive appraisals of the film that participants use a reappraisal regulation strategy, leading to an improvement of their mood. Future work could include a more throughout examination of potential regulation strategies used by asking the participants to indicate whether they attempted to modulate their emotion, the extent to which others' appraisals influenced this attempts and also how they regulated their emotion.

Conclusively, considering these findings, social influences used in **Study II** and **IV** seem to modulate individuals' wellbeing, however, whether they can effectively modulate the expression of affective memory (i.e. intrusive memories) warrants further investigation.

6.1.3 Social influences on the *transfer* of affective responses?

Affect spreads among people, both in face-to-face (Parkinson, 2011) and online (Fan et al., 2020; Ferrara & Yang, 2015) interactions. In **Study III,** we asked whether this process leads to the social transmission of threat (i.e., evaluating events or stimuli as dangerous) in an online setting. Using computational modeling, we estimated individuals' tendency to incorporate others' threat and safety evaluations into their own evaluations of negative pictures, and examined whether and how these processes influence individuals' own emotional responses. Our results showed that individuals' categorizations of pictures as threatening or safe emerged from integrating both their own distress ratings as well as how others categorized these pictures. These results suggest that in a digital social context, we weigh others' evaluation and our own affective response when evaluating content. We predicted that seeing others' threat categorizations would influence participants' categorizations of pictures as threatening more strongly than seeing others' safety categorizations. Interestingly, others' threat evaluations did not weigh more than others' safety evaluation when deciding on categorizing a picture as threatening or safe to share online. This goes against negativity bias suggesting that negative information would more strongly influence one's emotion or behavior (Rozin & Royzman, 2001) by indicating that in **Study III**, individuals equally integrate others' threat and safety online information. Importantly, the way threat and safety evaluations were operationalized in the design of this study meant that threat/safety evaluations were perfectly anticorrelated (i.e. all participant evaluations summed to 100 so if, for example, 55 provided threat evaluations then 45 provided safe evaluations, and vice versa). The concern was therefore that because of this

design feature, our model would not be able to correctly identify threat and safety parameters for each participant. In order to mitigate this concern we performed a number of additional analyses including model comparisons and simulations of parameter recovery. These results showed that threat and safety parameters were only weakly correlated across participants and model comparison indicated that the best fitting model for our data was in fact the model including both threat and safety parameters, even after penalizing for more complex models. Based on reviewer comments, we also ran two additional models, one including (1-θ) instead of the φ parameter and one other model including (1-φ) instead of the θ parameter. Comparing these two additional models with our main model (including both threat and safety parameters) would inform us on whether θ and φ were in fact redundant. Model comparison indicated that these models did not explain the data better, and that our main model including both threat and safety is still the best model. We also compared average predictive accuracy for the main model and the two additional models, which showed that our main model had a better accuracy predicting participants' responses at trial level, further increasing confidence in our main model.

Additionally, our findings then showed that individuals' affective response to a picture shifted based on how others categorized the picture. Surprisingly, we found that it is specifically how strongly one incorporates others' safety information into their own evaluations that was found to be related to how much one emotion is influenced. This suggests that the exposure to others' safe evaluation leads individuals to feel less distressed. This finding is supported by previous work showing that the exposure to social safety cues can immunize against vicarious fear learning (Golkar & Olsson, 2016). **Study III** extended our current understanding of how evaluate what is threatening or safe in their environment by showing that 1) peers' threat/safety evaluation of online content can propagate and emotionally influence others and 2) the observation of social safety cues in an online setting could prevent the maintenance of negative emotions following the exposure to negative content online.

Importantly, and as mentioned earlier, the design of this study does not allow us to speak of the specific affect diffusion processes leading to these results. Nevertheless, based on nature of our paradigm and our findings, we suggest that the transfer of affective response observed in **Study III** is due to social appraisal. As examined in the work of Parkinson and Simons (2009), future work could specifically test whether the emotional influence of others captured in our study is in fact mediated by individuals' appraisal (as we suspect) or by their own emotion.

6.2 GENERAL DISCUSSION

6.2.1 Practical implications

The studies presented in this thesis include innovative experimental paradigms (or combinations of paradigms) such as testing dyads of participants (**Study I**), adding the measure of intrusive memories to a standard threat conditioning paradigm (**Study II**), examining the spread of threat and safety evaluation online (**Study III)** and implementing the trauma film paradigm online (**Study IV**) to investigate social influences on affective responses.

One implication of these studies is that they brought experimental and clinical research methods together, which was not without challenges and asked for careful piloting. It is the collaborations between researchers from different research fields that allowed us to think outside the box while using good research practices to aid the translation from investigating basic mechanisms towards understanding processes involved in the phenomenology of psychopathology.

Additionally, using the Open Science Framework and making the studies' materials and methods available online, will hopefully allow other researchers to further use both our data as well as to test these paradigms.

Another implication is the digitalization of formally lab-based paradigms. Although originally done due to the COVID-19 pandemic, it allowed us to explore social psychological phenomena in the digital world by investigating a different form of social influence. The digital guidance developed and used in **Study IV** has already been shared with other researchers who have utilized it in a similar paradigm using traumatic films, and pilot findings seem to show a significant impact of the guidance on affective responses post film, compared to when no digital guidance is used. Knowing the high risk of non-usable data for online studies, such guidance could imply an increase in data quality with low time and money cost for the researchers.

6.2.2 Limitations

One general limitation of our studies is related to the challenge of analogue experimental research. For example, the use of a very controlled experimental paradigm enabled us to investigate specific basic processes involved in the development and maintenance of symptoms of anxiety-related disorders and PTSD. However, being less naturalistic than real-life contexts limited the ecological validity of our results. Using electric shocks or negative pictures or film as analogous to negative experiences is a limitation as the latter are usually more complex than the former. For example, real life negative experiences generally include more personal aspects such as the involvement of someone close to us. The stimuli used

in this thesis such as images of scenes or film depicting car accidents, are generic and might lack the particular emotional feature of real negative experiences.

Similarly, the use of very controlled social interactions allowed us to test specific types and valences of social influences, but limited us in the generalization of our findings to real life social influences. Social interactions in real life are more dynamic than the mere exposure to someone else's affective responses, which in itself might influence one's emotion-generative process.

Despite these limitations, analogous studies with high construct validity by focusing on underlying mechanisms are needed. For the development of evidence-based clinical intervention and the understanding of why and how they work, there is a need for experimental studies showing stable and replicable effects.

6.2.3 Future research

The findings of **Study I** instigate further investigation of vicarious threat learning using dyads. Previous work has shown that vicarious threat learning can be modulated by some of the characteristics of the person we observe, for example when observing someone belonging to our own social group undergoing a similar learning task (Golkar et al., 2015; Golkar & Olsson, 2017). Therefore, it would be interesting to test whether such effects are replicable using the live dyad testing.

Future work should test the replication of findings from **Study II**, showing that Pavlovian threat conditioning generates persistent intrusive memories. Such replication was designed and planned, however due to the COVID-19 pandemic, all lab testing was paused and the testing of this replication was never able to start. Such replication would be necessary to support **Study II**'s conclusions and continue the investigation of ways to reduce the number of intrusions by targeting threat memories using Pavlovian threat conditioning.

Future work should also continue the investigation of how online social influences can result in changes in affective responses. In both **Study III** and **IV** we show that the exposure to others' appraisals of negative visual content leads to changes in affective responses. It would therefore be interesting to further examine what aspects of the participants' appraisal changed. Was it a change in the appraisal of the visual content? For example, in **Study III**, did the picture of a dangerous gorilla was perceived as a big fluffy animal after seeing a majority of others saying it was a safe picture to see? Similarly, in **Study IV**, one could ask if individuals explicitly used a regulation strategy as a results of the exposure to others' positive appraisal of the film or whether it the broader meaning of the trauma film that changes.

7 CONCLUSIONS

The overall aim of this thesis is to advance the understanding of how social influences surrounding a negative experience can affect the formation, regulation and transfer of affective responses. Throughout four studies, we examined the impact of different kinds of social influences (face-to-face and online) surrounding various negative experiences (experimental analogues for trauma experiences), and how these social influences impact affective responses (from self-reported measures to physiological responses).

The overall conclusion of this thesis is that face-to-face and online social interactions can indeed influence each part of the emotion-generative process. Using an experimental analogue for trauma experience, we investigated how others can influence threat learning and the consolidation of learned threat. Our findings show that physiological synchrony between two individuals *during* threat learning may influence the formation of learned threat, but that the modulation of effect of different social support interactions *after* threat learning calls for further investigation.

Furthermore, digital platforms represent a very relevant setting in which others' affective responses to negative content impact our mental health (Hopwood & Schutte, 2017) (Hopwood & Schutte, 2017). We therefore developed online paradigms to investigate the influence of others' evaluation of online content on people's affective responses. Our findings demonstrate that people' integrate what others express online and that it influences their affective responses.

Importantly, these findings also illustrate the complexity of the investigation of the processes involved in social influences on affective responses. In fact, in the example at the outset of this thesis, the passenger's affective response to the plane turbulence is not due to the behavior or affective responses of one of the person around them in isolation. Rather, these processes happens simultaneously, influencing both the formation of the original affective responses as well as the regulation and transfer of already existing affective responses in parallel. Although our studies did not fully allow us to speak to the specific processes involved, their findings contributed to essential knowledge, bringing the research field closer to understanding how different kinds of social influences influence different kinds of affective responses.

8 POINTS OF PERSPECTIVE

The studies included in this thesis build on years of experience investigating emotional learning using threat conditioning (Olsson et al., 2020) and social regulation (Olsson et al., 2018), with psychological interventions (Holmes et al., 2018) and experimental approaches to aid mental health science (Holmes et al., 2014, 2020).

These studies have sought to bring together well-validated experimental procedures with clinical research approaches, which is not without challenges. Combining experimental and clinical approaches meant including more noise in controlled experimental paradigms to increase our understanding of the development and maintenance of central symptoms of anxiety-related disorders and PTSD. The strength of these studies was the collaborations across the fields of psychology and neuroscience. Such collaborations meant working with collaborators using different methods, different terminology and asking different questions. Nevertheless, such collaboration is needed for an effective translation from the investigation of psychological and biological mechanisms underlying human response to aversive events in social contexts, to clinical development of evidence-based interventions.

The results of these studies have sought to examine the implications of social influences on both face-to-face and online settings. As social human being, our emotions do not take place in a vacuum. Our social context and all its complexity is a source of information and influence on how we cope with what happens around us. It impacts our mental wellbeing and how we approach similar situations in the future. Moreover, as the digital world takes more space in our lives, both our behavior as well as our affective responses take new forms. Social cues are not always found on facial expressions and bodily postures but in likes, clicks, shares, film clips and reviews or comments. Social interactions online have been found to influence offline behavior in a positive way by for example increasing individuals' physical activity (Althoff et al., 2017). However, it has also been shown that what is shared within social media communities can also enable acts of violence (Müller & Schwarz, 2021). Our work looking at the way individuals' affective responses to online content are modulated by others demonstrate that we in fact integrate what others share and might use this information to regulate our own affective response. This work is just a small stepping-stone intending to inform of the spread of information online and its impact on the public's mental health.

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